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THE FIFTIETH ANNIVERSARY OF THE U. S. GEOLOGICAL SURVEY

SCIENCE IN THE GOVERNMENT[1]

OUR civilization is being made over right before our eyes under the stimulation of the forces set loose by discovery, research and invention. This new physical world has a firm basis upon undeviating universal laws. It is probably true that we have available a mere fragment of the great structure of knowledge which will eventually be brought into the service of man. Our view-points are rapidly changing. Old assumptions, theories and dogmas are being rapidly pushed out of our minds. In this period of mental ferment, shams have been exposed, the taboos of centuries released, and much has been brought up for discussion which was considered settled by our forefathers.

In the field of government there has been a rapid increase of democracy. To an increasing degree, science has become definitely associated with the development and functions of government. This is the age of democracy and science. Science has no sympathy with substitutes for the truth. Science is giving the human family a unique and unexampled service, and through it the human mind has been vastly increased in its range and mental power.

With the development of the democratic idea and the elimination to a large degree of the divine right of rulers, the necessity of wise leadership selected by democratic processes becomes a paramount need. This is the day of the expert. The man who knows must be recognized and used. In the fields of science the experts can be trained and developed, but such experts require opportunity for long years of study and they need constant exposure to those who are devoting their lives to research; in fact, progress in our modern civilization is going to depend upon the experimental method rather than upon catchwords, aphorisms or the persistent broadcasting of untried ideas. So close to-day is the link between science and its laboratories and the government that we can measure the progress of a civilization by its economic capacity to support laboratories and by the quality of the intellects brought into them.

It has been customary in government with the needs of agriculture, public health and in other fields to set aside a certain amount of money and certain

[1] Address delivered in Washington on March 21, 1929, upon the occasion of the celebration of the fiftieth anniversary of the foundation of the U. S. Geological Survey.

bureaus for those studies requisite for security. There has been too a fortunate tendency to increase the amount of work done in government laboratories which can be classified as of a fundamental character—that is to say, searching for truth for its own sake rather than for practical procedures immediately applicable to daily life. Essentially research depends upon a large amount of reserve time which can be used by men of great curiosity and industry without the supervision of others except in the broadest way. The ordinary administration of government, the ordinary handling of budgets, do not lend themselves well to research. It requires its own technique. In it there will always be an apparent waste of time and false leads. Most leads in the great unknown are apt to end blindly. The discovery of new facts which once discovered become the eternal property of man, is full of hazards and uncertainties. In some ways the research worker has as difficult a task as that of a blind man trying to thread a needle. Many attempts must be made before success is assured. Because of this it is most important for the modern democracy to set up its relationships to science from the standpoint of the budget in such a way that funds will not be tagged for specific purposes. Funds should be made available for the securing of the best brains possible and for the facilities that they require, in order to pursue the unknown. While this function is carried on by many independent institutions and as a part of great industrial concerns, nevertheless it seems to me that, since science and government are so closely related, government itself must make liberal grants for investigation and research. In the new world's civilization which is now a world-wide structure, interlocked economically and with all kinds of interrelations and intercommunications, a new conception of world citizenship is developed. Truth discovered by the citizen of any country can readily become the property of all. A democracy which is not seeking for new truth and new facts can no longer consider itself safe in this world of harsh reality where facts determine the issue. These facts applied either to industry or to national defense determine not only progress but even safety.

The U. S. Geological Survey is an example of the service which science can render to government. The geologist with his trained mind has made a study of that part of this great continent which is in our possession. Through years of endeavor and the work of thousands of trained men, we possess a fund of information regarding our mineral, water and soil resources which guides much of our national policy in various fields. It is obvious that without the help of the expert we should have floundered in our conquest of the natural resources of the country. Upon the imaginative mind of the geologist and his capacity to visualize the treasures stored below the surface of the earth depends much of our future national welfare. In the Geological Survey we have had much that was practical but also much that was fundamental.

It is a privilege for me to congratulate the men here who represent in person the great services rendered to our country through this particular activity. In them we see the scientist in the service of government. If we can develop in other fields the same type of devoted and earnest and intelligent service that characterizes this survey, we can look with assurance upon the future of our people. But this assurance can only be secured by an understanding on the part of the citizens of our democracy of the true place of science. Majority votes may determine political activities, but they can in no way influence the laws of nature or those of science. A wise democracy will harmonize its program with them. The scholar and the research worker must have the freest initiative to pursue truth, no matter where it may lead, if we are to avoid the perils of ignorance.

RAY LYMAN WILBUR

DEPARTMENT OF THE INTERIOR

THOMAS JEFFERSON, THE PIONEER OF AMERICAN PALEONTOLOGY[1]

IN 1789 the Reverend Nicholas Collin, an accomplished botanist and acquaintance of Linnaeus, remarked before the American Philosophical Society at Philadelphia:

> The vast Mahmot is perhaps yet stalking through the western wilderness; but if he is no more, let us carefully gather his remains, and even try to find a whole skeleton of this giant, to whom the elephant was but a calf.

Collin was one of the prophets of American paleontology, with whom we may rank other historiographers—such as, Samuel Maverick (1636); John Bannister (1686); the French officer, Longeuil (1739), who took the teeth of a mastodon from the mouth of the Ohio River to the great French naturalist, Buffon; also the pious Cotton Mather, who in 1705 described the mastodon remains found at Albany as those of a human giant, and Dr. William Hunter of Harvard College, who remarked to his medical students in 1767 regarding the mastodon:

[1] Address delivered in Washington on March 21, 192[9] on the occasion of the fiftieth anniversary meeting of the foundation of the U. S. Geological Survey.

If this animal was indeed a carnivore, which I believe can not be doubted, though we may as philosophers regret it, as men we cannot but thank Heaven that his whole generation is probably extinct.

But the pioneer of American paleontology was Thomas Jefferson, third president of the United States, a real genius, eager for exploration and exact knowledge, jealous of the prestige of his country even in the prehistoric past. For did he not in his first public paper of scientific import in 1781 refute the assertion of Georges Louis Leclerc, Comte de Buffon, that the living animals of America were smaller than those of the Old World and that on the whole America had produced fewer species? He proved his point by sending a giant American moose to Paris. The signal gun of American paleontology was that which he fired in 1797, when in describing the so-called "Great Claw" or *Megalonyx* as found in the floor of a cavern in Virginia, Jefferson concluded that the creature was a lion three times as large as the royal beast of to-day and wondered what had become of the monster:

A difficult question now presents itself. What is become of the Great Claw? . . . In the present interior of our continent there is surely space enough . . . for mammoths and megalonyxs who may exist there. Our entire ignorance of the immense country to the West and Northwest, and of its contents, does not authorize us to say that it does not contain. . . . In fine, the bones exist; therefore the animal has existed. The movements of nature are in a never-ending circle. The animal species which has once been put into a train of motion, is still probably moving in that train. For if one link in nature's chain might be lost, another and another might be lost, till this whole system of things should vanish by piecemeal.

Jefferson had been imbued with the evolutionary spirit of Buffon. He was no longer fitting *Megalonyx* and *Mastodon* into the story of the Mesopotamian flood. He was as keen to introduce the scientific spirit of France which arose under the monarchy as he was to exploit the political theories which found expression in the Revolution. His paleontology did not rest with *Megalonyx* but continued to be his favorite avocation, the subject of correspondence and eager interest in the successive discoveries of mastodon remains along the Hudson (1801, 1806), and in the arrival of 300 specimens of fossil bones brought to Washington from the Big Bone Lick of Kentucky by General William Clark upon his return from his famous Louisiana exploring trip with George Meriwether Lewis (1804–06). The Lewis and Clark expedition and that of Pike to his lofty Peak in 1806 were favorite projects of Jefferson and owed their congressional support—of $2,500 in the case of Lewis and Clark—to the president's persistent backing. As Theodore Roosevelt, in the year 1910, relaxed after his prolonged combats with the Tammany tiger by reading Osborn's "Age of Mammals," so Jefferson after his constitutional struggles with Aaron Burr found his "supreme delight" in the "tranquil pursuits of science."

Following this great pioneer, the science of vertebrate paleontology, so named in France by its father Cuvier, slumbered for several decades in America, feebly nourished by the work of state geological surveys, under such men as Lardner Vanuxem in New Jersey; Amos Eaton in New York; David Dale Owen and Richard Owen in Tennessee, Wisconsin, Indiana and Illinois; Ebenezer Emmons in North Carolina, and Caleb Atwater west of the Alleghenies. The science was brightened in 1826 by Mitchill's discovery of the first fossil horse; in 1834 by the discussion aroused by Harlan's Zeuglodon, whether it was a giant reptile—Basilosaurus meaning the emperor saurian—or a mammal, and in 1846 by Dr. John Warren's purchase of the superb mastodon of Newburg, which now bears his name.[2]

But by far the most signal event of the year 1846 was Prout's description of bones brought him by a fur trader from Nebraska, as *Palaeotherium giganteum*, a titanothere now known as *Menodus giganteus* in the present Survey Monograph, Number 55. This opened the new era, anticipated in the brilliant mind of Thomas Jefferson when he said, "Our entire ignorance of the immense country to the West and Northwest and of its contents, does not authorize us to say what it does not contain"; for in the whole period of American history previous to 1846 only fifty-nine kinds or species of fossil fishes, crocodiles, various reptiles and mammals had been described, as contrasted to the subsequent long period of American supremacy in vertebrate paleontology, which yielded through the genius of Leidy, Marsh and Cope a total of 2,180 new species and genera, and caused North America to be regarded as the very heart of the vertebrate terrestrial life of the world.

Thus the scepter passed from France, and North America became the chief seat of the world's learning in the science of ancient life.

The leaders of the four original geological surveys of the western territories, from the very first, appreciated the importance of vertebrate paleontology, although Major Powell concentrated his energies more particularly on studying the life of the western Indians. Joseph Leidy, who between 1847 and 1869 prepared his great monograph, "The Extinct Mammalian Fauna of Dakota and Nebraska," culminated

[2] Dr. Warren described this animal in 1852 and became an authority.

his life work in expounding for the Hayden Survey the Middle Eocene of Southern Wyoming: the Bridger region. Both Wheeler and Hayden chose Cope, who was thus led to the Basal Eocene of Southern Colorado and New Mexico and the Lower Eocene of the Big Horn and Wind River region of Central Wyoming, and compiled his bulky "Memoir," known as "Cope's Bible," and said to have been the despair of the Government Printing Office because of Cope's constant and voluminous corrections.

Marsh, chosen by Clarence King for the 40th Parallel Survey, alone survived the consolidation of the four original surveys and went with King into the U. S. Geological Survey, the half century of which we are celebrating to-day. Here he projected six colossal monographs on the extinct birds, giant reptiles and mammals, each to be illustrated by lithographic plates of surpassing size and beauty. He lived to complete only two of the volumes, namely: the "Odontornithes" and the "Dinocerata," leaving to members of the third and fourth schools of vertebrate paleontologists—Hatcher, Lull, Gilmore and Osborn—the completion of this mighty undertaking, which still lacks the final great Sauropoda volume. Meanwhile Scott and Hatcher mastered the paleontology of Patagonia.

Now a fourth school is arising, younger men full of talent, who are not only extending the findings and work of Leidy, Marsh and Cope, but are carrying American field methods, energy and enterprise into Mexico, Central and South America, Cuba, the Antilles, North and South Africa, Java, the Pliocene of the island of Samos, Maragha, Persia, the ancient Siwaliks of India, the Tertiary of China and the Mongolian heart of Central Asia. Little did our pioneer Thomas Jefferson imagine that vertebrate paleontologists of America would some day penetrate even the classic grounds and classic specimens of western Europe and revise from an evolutionary standpoint the specimens and work of Blumenbach, of Cuvier, of Falconer, of Gaudry, of Owen and of Huxley: founders and leaders of the great European schools.

Of personal memory is the profound learning and dignity of Joseph Leidy, the eager brilliance of Edward Drinker Cope and the fundamental and expansive labors of Charles Othniel Marsh. Of these very diverse personalities it may be said that each possessed the scientific qualities which the others lacked; they were complementary characters. The intense rivalry between Cope and Marsh spurred them to greater efforts in exploration and to more lavish expenditure, not only of government but of personal funds, which while it impoverished them, certainly enriched their science and resulted in the vast collections now housed in the U. S. National Museum, the Peabody Museum of Yale University and the American Museum of Natural History, which conserve for all future research types of the 1811 species, genera and orders of vertebrates which these two remarkable men described.

It was the great personal charm of Clarence King, first leader of the U. S. Geological Survey, when his 40th Parallel Survey was housed in the upper floor of the American Museum of Natural History, which first fascinated me with the work of a geological survey: the beauty of his maps, the imposing character of his reports. This fascination doubtless influenced my own final entrance into the service of the survey in 1900. Hayden, brought up amidst the historic influence of the old scientific societies of Philadelphia and familiar with such men as Joseph Leidy and the great paleobotanist, Leo Lesquereux, lent to his surveys a breadth of scientific culture which has never been surpassed. Nor in these personal reminiscences could I fail to recall my genial and inspiring experiences with Major John Wesley Powell, the successor of Clarence King, with whom I took up the publication by Dr. W. D. Matthew in 1915 of the plates for the second volume of Cope's Bible, entitled "Hitherto Unpublished Plates of Tertiary Mammalia and Permian Vertebrata."

But most of all I value the peerless leader, Charles D. Walcott, who not only entered the survey for a long and distinguished period of administration, but contributed several memoirs on early Cambrian faunas which rank among the great classics in invertebrate paleontology. In the spring of 1900 he invited me to succeed Professor Marsh as vertebrate paleontologist of the survey. I accepted this great honor and entered upon the task with confident enthusiasm that in the course of the next three years the text and illustrations of the projected Titanothere monograph would be completed. But these early anticipations were soon frustrated by the discovery that a new and very intensive geological examination of the Eocene and Oligocene Tertiaries was essential; that all the species and types of Leidy, Marsh and Cope had to be reexamined with microscopic accuracy and that a new paleontologic philosophy founded on the Titanothere researches and the fifteen-million-year period during which they flourished was necessary. And so twenty years elapsed before the promised manuscript reached the editorial department of the survey, and no less than nine years elapsed before the last word and final correction was added to the page proof. Meanwhile has occurred the discovery that the homeland of the Titanotheres was not in America, but in Central Asia, and at the last dramatic instant the final stage in the evolution of these giants was condensed into the blank pages at the end of the Titanothere volume: pages 943–945.

It would be impossible in this all too brief review to fairly distribute credit and rightly award the laurel crowns to the long line of explorers, geologists and paleontologists who have wandered from the banks of the Ohio and Hudson to the great deserts of America, of Africa and of Asia, from the pioneer period of Jefferson to the present flourishing period of the U. S. Geological Survey under its fourth director, George Otis Smith, and the Geological and Paleontological Societies of America.

Let it be said that throughout its entire history, our survey rightly crowded and pressed as it has been with the demands for economical surveys, researches and publications, has held aloft the torch of pure science and generously sustained the closely interweaving sister sciences of paleontology and geology.

HENRY FAIRFIELD OSBORN

AMERICAN MUSEUM OF NATURAL HISTORY

THE POTENTIALITIES OF ENTOMOLOGY[1]

WHAT came to your minds as the most important potentialities of entomology when you first read this title, I do not know. If I belonged to the new school of educational psychologists, I would find this out by giving you questionnaires to fill out. But I have such an aversion for this parasitic method of absorbing information that I prefer to commit the crime of guessing rather than steal your time. I will guess that the economic potentialities were among the first to present themselves.

The economic potentialities of entomology have certainly impressed the public. Give us a few more insect outbreaks and importations and we will be as respectable in the eyes of the public as a steel corporation. The man of the street who used to question the advisability of letting men interested in bugs enjoy the same freedom as normal individuals is becoming rare. In fact if one of the public were to ask an entomologist for an excuse for his existence to-day he would soon find himself so embarrassed by the economic arguments that he would feel it necessary to apologize for intruding upon the earth during the age of insects and would have to end his interview by thanking the entomologist for permitting him to continue his existence. From present tendencies the day may come when entomologists will be more in the class of diplomats than scientists. They may be ministers biopotentiary who will arrange for the coexistence of man and insects and will take the necessary steps to see that the movement of man and his articles of commerce from one geographic region to another will not be attended by any serious biological embarrassment.

Some time ago I was called upon to give an account of myself to determine whether I was entitled to certain advantages that I had asked for. After making a case for my project and its scientific significance as best I could, I mention a by-product of the work which involved no real scientific ability at all, but which incidentally saved seventy thousand dollars worth of goods and a million dollars worth of business for a corporation that really didn't need either. This one reference to economic importance trumped all the rest of the case. Even though the judges themselves were scholars, they reacted more quickly to the language of our economic age than to the logic of science.

I realize very well the value of the economic card, and I know that it is usually the trump, but I am not going to play it this time. I take it for granted that we are all aware of the economic potentialities of entomology, but I wonder if we give enough thought to certain other potentialities? Do we consider the potentialities for scholarship and culture?

I have a friend who is a business man of ability, and it happens that entomology has considerable economic importance in his field. In discussing research in entomology he once made the statement to me that he could not conceive of any one doing research work in entomology who did not have, directly or indirectly, as his ultimate aim some economic application of his work. This is not an unusual attitude, not only toward entomology but toward any branch of science. There seems to be a general feeling on the part of the public that a scientist must justify his time in the laboratory on the basis of the economic importance of the results that are to come from the work he is doing.

The public has come to have the attitude of the professional beggar—it expects something from everything that a scientific man does. But the public isn't entirely responsible for this view-point. We have schooled it in this attitude. We apologize for work that is undertaken from the standpoint of original scholarship by saying that no one knows what economic importance the results may have at some future time. Why not justify such work on the grounds that the results sought after are significant in the realm of knowledge, rather than try to make an economic case out of it by some stretch of imagination? I am of course ruling out all work that is designedly economic. Society is rightly entitled to economic benefits from such work, and I may add,

[1] The annual public address by invitation of the Entomological Society of America, delivered on December 28, at New York.

parenthetically, that it usually does receive them from all scientific research. I am simply making a case for scholarly scientific research on the basis of scholarship itself.

Society does not require an artist to justify a great painting on the grounds that those who look at it will thereby be able to earn more money or that they can save money by looking at it. If the artist can execute a masterful depiction of some beauty of nature, some great human emotion, or some great conception of the mind, society accepts his contribution as such. Poetry is not judged as to whether its lines are applicable to sales talk or whether the study of it will make or save money. There are at least a few people who can find time to look at pictures and read poetry for the satisfaction they can get out of them—because it makes their lives richer than they were before.

What economic justification is called for when a research program is carried out to prove significant facts that open up a new world to human thought? A problem is well conceived, a working hypothesis is formulated that calls for the determination of certain unknown quantities in an obscure field. The experiments are executed with ingenious and painstaking skill, overcoming the greatest technical difficulties which hitherto shut these unknowns from the human mind. All the resulting data are arranged in logical order and with perfect intellectual honesty. The conclusions are logically drawn and are presented in a masterly fashion, leading to a whole sequence of new conceptions and appreciations. The conception of a great hypothesis is a noble flight of imagination guided by an unfailing logic, its substantiation, an example of intellectual strategy; and its results open up an avenue by which the excursions of the mind may escape from the universe that formerly confined them. Surely research of this order stands on its own as intellectual achievement and should be accorded no less of the rights and recognition of culture than go to art, music or literature.

We must make certain reservations with regard to the cultural value of entomology. It is not contended that all the factual knowledge of entomology is of cultural significance. But in so far as the study contributes to intellectual refinement and enlightens man as to his place in nature, it certainly is of cultural significance. And in all nature there are no more available opportunities for cultural development than in the study of insects with their diverse forms and highly developed social habits. Unlike museums and libraries they are to be found everywhere.

Let us now turn our attention to the present status of entomology with respect to scholarship and culture. If science rises above the economic strife to enter the field of intellectual achievement, where does entomology stand in this realm? If we answer the question honestly, and we can not do otherwise, we must say that it does not rank very high. In hardly any country save America is it deemed worthy of a professorial chair in a university. England has one such professorship. Germany has none—and what is more, if a young zoologist were to devote himself to a study of insects he could not even hope to occupy a chair of zoology in a university. It is true that there are professors of applied zoology in forestry schools who are essentially entomologists, but they are nevertheless professors of applied zoology. Even at the University of Rostock, where a special course of study in entomology is outlined, the man in charge is a professor of applied zoology.

France has no entomology taught as such in the universities which are under the Ministry of Public Instruction. Entomology is taught in the agricultural institutes under the Ministry of Agriculture, but there are no professors of entomology. Dr. Marchal is director of the Entomological Station but his title is professor of applied zoology, and the entomology which is taught in his institute is not officially recognized by the universities of France because they are under a different ministry.

This general condition in Europe is not due entirely to the recognition of the fact that entomology is but a special branch of zoology, which is a perfectly correct view. It is due to a judgment that entomology is not on the same scholastic plane with the general field of zoology, and this view-point is not confined to Europe. It exists in America. I hold two part-time professorships in a university, and from my superior plane as professor of zoology I can look down upon myself as a professor of entomology with mingled feelings of scorn and pity. I can also reverse the process and look up with real envy to my superior position as professor of zoology. So long as my interests are as they are, it is fortunate for me that I am in this dual position. If I were in almost any country other than America and were to occupy a professorial chair at all, I would have to be a professor of zoology and "bootleg" the entomology or else leave it alone.

With regard to culture, the situation is almost worse in America but better in Europe. One of my colleagues recently surprised me by questioning whether even certain phases of general zoology could be considered as cultural, and some of my literary friends shudder at the thought of admitting science in any form into the realm of culture. Europe will probably concede us more from the standpoint of culture but possibly less from the standpoint of scholarship.

Now this is the situation and we may as well face it honestly. I have thought about it a great deal as I have visited universities and attended scientific meetings in various parts of America and Europe. Incidentally, it may occur to some of you that I have personally an easy way out of the dilemma, at least so far as scholarship is concerned, by ascending to my zoological chair. But this does not let me out of it entirely, for confidentially, I am not all there in the field of zoology, as an essential part of me is inextricably fixed in the field of entomology. This is a real, though fine, distinction, for you recognize the fact that a zoologist may study the genetics of Drosophila and not be an entomologist. In the zoologist's study of animals he may accidentally study insects, but the entomologist studies insects by purposeful preference.

It is not going to do any good to complain about the verdict that has been rendered in the field of science or culture. Let us put aside all feelings of injustice and accept the verdict as it stands. Let us examine the situation and see what has led to the present condition and then not ask that standards be lowered because of special conditions surrounding our situation, but look to the future and see to it that our achievements are such that any standard of recognition will have to accept us, not in the questionable lower levels, but fully abreast of any other branch of science.

It has been the history of the various branches of science that they have begun with qualitative observations and pure descriptions. Later, they have developed methods of technique for quantitative work and experimentation. Hypotheses have been built up and principles established that are based upon calculations involving highly technical quantitative methods. In the biological sciences the work began with description of species, habits and life histories. Later on, the development of the microscope and other technical equipment made possible the examination of more minute structures. During the Darwinian period, observations tending to uphold the theory of evolution so dominated everything in the field of biology that experimental work was almost forgotten. Quantitative experimental work in physiology, biochemistry and biophysics, which deals with the energy relations of organisms, constitutes one of the important recent developments that have found application in the fields of agriculture, industry and medicine. At the present time we have new methods, new theories and new principles rushing into literature at such a rate that most of us wonder how we are ever going to keep up with the trend of the times. It is true that many of these are fads and fashions, but many are of fundamental importance.

The mere fact that there are more species of insects than of all other animals together has resulted in more systematic work in entomology than in all other branches of zoology taken together. This great task of distinguishing and describing the vast numbers of species of insects, many of which are even now unknown, has proven not only time-consuming but fascinating. Consequently while the entomologists have been absorbed in this great task of pure description, workers in other branches of zoology have forged ahead into a more advanced field, involving experimental and quantitative methods. The great resources of entomology have proven a handicap. Lost in the wealth of material of which other branches of zoology might well be envious, it has not been able to keep pace with the progress of the day. Vast numbers of amateur workers have flocked to the field, attracted by the wealth of material. Some of these, it is true, have been actuated by the same stimulus that prompts the school-boy to collect stamps, but many others have come with true cultural desire, and they have been stimulated by the intellectual activities involved in the describing of species and the study of the habits of groups of insects. These constitute a very important element in society. They acquire a certain intellectual refinement that is difficult to get in any other way than by close contact with the facts of nature. They are a stable element in many of the European countries. It is difficult to conceive of such a group being swept off its feet by any anti-evolution propaganda. They know too well the facts of nature learned at first hand.

While entomology has made a very important cultural contribution in this way, it has, at the same time, done it at the expense of its own scholastic standing. The result is that zoologists have considered entomologists as nothing more than describers of species and habits. They have pointed out in many cases that some of the more important contributions in this line have been made by amateurs who have had no adequate schooling to qualify them to rank as scientists.

A second great resource to which entomology has fallen heir has proven not only a benefit but a handicap, that is, its economic importance. I have eliminated this from direct consideration, but we must introduce it here indirectly as an important factor in impeding the progress of scholastic work in entomology. We are in somewhat the same position as the newly rich with considerable economic prestige but not enough culture to get into the best society. An enormous army of entomologists has been called for to combat insect pests. Outbreaks have occurred that have amounted to catastrophies. Unfortunately from the scientific standpoint, there has been little correla-

tion between the type of scientific work involved and the economic results obtained in combating insects. Some of the most serious insect outbreaks were often successfully controlled by methods that would suggest themselves to any high-school boy. Entomology is not the only branch of science that has suffered in this way. The same thing has been true in medicine. Some of the earlier remedies were arrived at in a perfectly obvious way.

The fact that many untrained entomologists have been able to make marked strides in combating insects, yielding good economic returns to the public and attracting considerable attention to themselves, has caused the other branches of science to look down, possibly partly with envy but certainly partly with a feeling of scorn, at a field in which progress was made without any training in the fundamental sciences. However, as the more obvious problems have been solved and cleared away, we are approaching the time when we, like medical men, will be face to face with some difficult and involved problems which will demand the very best that our next generation can produce in the way of keen intellect, sound training in the fundamental sciences and the development of the most advanced technique for experimentation and the most refined biometrical methods for interpretation.

So it appears that entomology is behind the times, that her professionals are so indistinguishably mixed up with her amateurs that they have lost caste with the men of science. But these qualities are not altogether bad. Any large object gets under motion slowly, offers considerable resistance to the change in its course, but in the end may go farther than the smaller ones. Last summer Dr. Wheeler remarked, as we sat watching the entomologists assemble for one of the meetings of the International Congress, that he had always been interested in entomologists as such, that they seemed to have a conservative attitude that was quite a contrast to the fads and fancies that seem to dominate the zoologists, who are interested in one thing one year and in another the next. This remark was intended as a compliment to the entomologists rather than a reflection on the zoologists. But before I have finished you may have me classified as one of the erratic radicals if you have not already put me there.

The situation that confronts us is not a calamity but a great opportunity. I might have used the title "From Stumbling-blocks to Stepping-stones." The characteristics of entomology that have made its progress slow in the past are the greatest potentialities for its future. A fellow entomologist once remarked to me that he wished that he had lived in the time of Linnaeus when every species he got hold of could be given a new name. But I don't. If I were to live in any other generation than this I would rather that it would be the next one. I wish all the species were described and the keys fitted to a slide rule that always worked.

Let us now consider the cultural potentialities which may come out of the amateur's interest in entomology. A year ago I was on leave of absence for fifteen months and had the first opportunity to think that I have had since I was promoted to be the head of a department. I saw professional and amateur entomologists in various countries and reflected upon the conditions in America, from a distance. It was my privilege to come in contact with some of the amateur entomologists of Europe. I visited them personally and saw them collectively in the meetings of their societies. I was greatly impressed with their interest and was convinced that most of them went beyond the mere collecting of insects or the mere observing of insects' habits. They reflected upon their observations. They built up a philosophy of life far above that of the average person. Some of the professionals who attended these meetings with me were inclined to treat lightly some of the questions asked and the subjects discussed by these laymen. But I took them rather seriously. I think they have a great stabilizing influence on society, and with many their interests in entomology dominated their lives. In southern France I came in contact with the late Mr. Powell, an amateur entomologist, interested in Lepidoptera. He adjusted his vocation to his avocation. He was greatly interested in the fauna of Morocco and he later moved his family there, establishing himself there for the main purpose of being close to the things he was interested in, and he died there. The story of Fabre is too well known to us all to require repeating. His influence will live for generations.

In an age that is so marked by material progress I think we can do well to consider the cultural progress at the same time. We are told that the rapid increase in the use of machinery in industry is going to free men for greater leisure. But what are they going to do with their free time? From the appearance of our parks, boulevards and trunk highways most of them spend their time in driving around, and about as many are going in one direction as in the other. Dr. Friederichs tells me that the interest in the study of nature and other cultural activities in Germany is giving way to an interest in athletic sports. I was much impressed by Germany's interest in athletics for personal physique but I think it would be a mistake for this to develop to the exclusion of an interest in cultural activities.

In America I believe that this situation is serious. We have, in general, the material well-being that is necessary as a foundation in culture, for culture does not thrive with want and suffering. But as we are being freed from our physical worries are we becoming interested in cultural subjects? In entomology, with its wealth of available material, there is a great opportunity to stimulate our citizens to study nature for the sake of its cultural values. Our local, state and national parks can become something more than areas to race through in automobiles, and our own back-yards can become fascinating places in which we can spend delightful and profitable hours in studying the nature of which we ourselves are a part. The small entomological societies composed of amateurs are a very stimulating factor in this connection. Their contributions to science may not amount to much, but their contributions to the human welfare and culture may amount to a great deal. It is true that there will be a certain strain upon professional entomologists by way of answering questions or lecturing. But I think we need not worry about losing caste by contact with them any more than the teacher may be dragged down by his pupils. They may be a stimulus rather than a hindrance. It is not ours to forsake society and withdraw into a hermitage. If we believe as much in democracy as we say we do we shall have to indicate it by our acts.

Now let us consider the potentialities of entomology in the realm of scholarship. We find ourselves classified as in a descriptive science for reasons that I have already given. Perhaps we will never be through with the describing and perhaps we should never be through with it. One of the fundamental questions before us in the field of biology to-day has to do with how new species arise, and we probably have derived as much information, or more, from the study of insects as from any other group of organisms, in making progress on this question. You may say that the entomologists are not the ones who made the contributions. Zoologists borrow the insects for the purpose of genetical study. Many important problems of the more advanced type have resolved themselves out of the field of entomology and more will follow in the future. If an investigator studies the physiology of insects he comes into closer contact with other physiologists than with other entomologists, and he soon finds himself a physiologist. Similarly, one who is devoted to the study of the genetics of insects soon finds himself in closer relationship with other geneticists than with other entomologists. This will probably always be true; probably it should always be true. If, out of the great army of describers, there come forward only a few individuals who become leaders in making contributions to our knowledge of the origin of new species, whether they later become geneticists or physiologists or biophysicists, entomology will have made a contribution of which it may be justly proud.

Turning our attention now to the hosts of people who are describing life histories, we find an ever-increasing number of students coming for graduate work who say that they are principally interested in life history studies. This is an appealing type of work and its elementary stages require very few prerequisites. But if one goes far in this field he comes up against some of the most fundamental problems, which rest basically upon the fundamental sciences. I believe it is safe to say that one of the greatest perils our modern students face is that they build their pinnacle of information so high that it begins to topple for the want of a solid basic foundation. When I was making up my program as a freshman in college, I took it to my adviser, and he called my attention to the fact that the mathematics I had included was not necessary, as I was going to major in biology. And now I would be willing to trade forty-five credits of any of several spare subjects to any one who would deliver to me the equivalent in mathematics.

The field of ecology in which I am personally interested is rapidly becoming complicated. On the one hand, we are pushing into the field of physiology for information on physiological effects and responses, a field that has been altogether too much neglected by entomologists—one that is almost unlimited in its possibilities but that demands good training in the fundamental sciences in order to make significant contributions. On the other hand, we are pushing into a newer and no less significant field of biocenosis, which deals with the systems of populations and the effects and the responses involved with physical and biotic factors. In this field we stand in the same relative position occupied by physical chemistry before Willard Gibbs made his great mathematical contribution that forms the basis of that branch of science. Entomology has the natural resources for making the greatest and most leading contributions in this field of ecology. Here, again, I fear that there is a tendency for the economic importance of the subject to run away from the scientific importance. We have for a considerable time realized the importance of parasites in controlling insect populations, but we have no fundamental information as to the trend of the populations of hosts and parasites, prey and predators, or as to the effect of physical factors on the trends of these populations. Fortunately, Dr. Vito Volterra, professor of mathematics at Rome, has

become interested in biological fluctuations and has issued a series of publications, outlining from the standpoint of a mathematician the trend of populations beginning with simple cases where two species contend for the same food, and then adding a factor at a time until a complicated association is built up, including the possibilities of forcing and damping the fluctuations by physical factors. From these calculations he has deduced certain laws that govern the cases where certain assigned coefficients apply. This work, I believe, is destined to take its place along with that of Willard Gibbs so far as significance in the field of science is concerned. Here, then, is a great opportunity to show that these mathematical theorems do or do not apply in the field of nature. It is a wonderful opportunity and I wonder if we are equal to it. We are dealing with populations in which organisms are units just as the physiologist deals with organisms in which organs, tissues and cells are units and as the physical chemist deals in systems in which colloidal particles, molecules, atoms and electrons are units. It is infinitely complicated and infinitely fascinating.

To summarize, we have in entomology a wealth of material and it has taken us a long time to get over some of the more elementary stages in our progress, but the great extent of the field is one of the most promising things in our science. The character of much of this material is such that it is destined to aid greatly in bringing to the public in general an appreciation of nature, thereby making a great contribution to our cultural life. But our age is moving pretty rapidly and, if we are going to get this before the public and see that our society maintains its well-balanced poise, we must all of us be active. Those to whom entomology is an avocation must take the obligation seriously to see to it that society, in its enthusiasm for material progress, does not forget some of the finer things of life.

In the field of scholarship our future is bright. No one can deny the wealth of material at our command, and I believe we have no reason to feel ashamed of the records of the past. Let us not spend any time in denouncing the verdict as to the scholastic position of entomology at the present time. Let us see to our own attitudes rather than decry the attitudes of others. It is difficult to maintain our scientific poise against the enormous economic pressure that comes upon us, but let us do it at all costs, knowing full well that it is in scholarship that our ultimate salvation lies.

Let us look to our scientific spirit. It has been my conclusion, after visiting many of the entomological laboratories of Europe and America, that the one most important factor for scientific progress is the spirit of the research man himself. Given a certain threshold value of material laboratory equipment, beyond this there is nothing that determines the significance of results more than the spirit of the man who is doing the work. And how costly is the petty administrative dictation which dampens such spirits and thereby deprives science of the most precious acquisitions of a laboratory! If this is true of individuals, it is certainly true of groups.

Even scientists themselves become enemies of progress when there is strife between them. One of the most discouraging tendencies of scientific progress is that of the crowd to down the man who steps out in advance, regardless of who or where he is. This does not imply the exclusion of friendly rivalry or the suppression of criticisms of questionable hypotheses. It is a plea for both individualism and cooperation in research and, above all, intellectual honesty in the spirit of research. Remember that when facts are accumulating for or against a hypothesis they are not accumulating for or against its author. If he is intellectually honest, his hypothesis is a tool for progress which is gained by proving or disproving it.

So in this day of organization and super-organization, of budgets of money and budgets of time, of teaching loads and weighted credit hours, of research project statements and reports, and even of achievement tests, I still say that the most important thing in scientific progress is the spirit of science itself. My recommendation for the progress of entomology is to turn absolutely free in the field all such great spirits that can be found, unburdened by the regulations of organizations, with no dictation as to the form of the final report, but with infinite trust in the spirit of research.

ROYAL N. CHAPMAN
UNIVERSITY OF MINNESOTA

SCIENTIFIC EVENTS

THE NEW HARVARD CHEMICAL LABORATORIES

THE formal opening of the Mallinckrodt and Converse laboratories was held last week, when the donors were entertained at a reception and dinner. Among those present was Mrs. Edmund C. Converse, widow of the late president of the Bankers Trust Company. Mrs. Converse and her family gave the Converse Memorial Laboratory in memory of her husband. Mr. Edward Mallinckrodt, Jr., represented his father, the late Edward Mallinckrodt, of St. Louis, who gave the first large sum, which made the new laboratories possible.

The Mallinckrodt Laboratory will house practically ll of the undergraduate courses in chemistry. The op floor is devoted to elementary chemistry, inorganic hemistry and qualitative analysis. The second floor ontains the Horsford Laboratory given by Mrs. Villiam G. Farlow, widow of the former head of he chemical laboratory. This laboratory is devoted o quantitative analysis; the remainder of the floor devoted to elementary organic chemistry. Physical hemistry, electrochemistry and photochemistry are laced on the first floor. Industrial chemistry is proided for in the Bradley Laboratory, given by Robert . Bradley, president of the American Agricultural Chemistry Company, in memory of his son, Robert S. Bradley, Jr. This occupies part of the first floor and he basement.

The Converse Memorial Laboratory is devoted priarily to research in organic chemistry. It also conains on its top floor the course in advanced organic hemistry. The new chemical library is housed in his building.

The equipment of the new laboratories is advanced d complete, in great contrast to the old Boylston aboratory which for years housed Harvard's chemtry courses. Seven professors' suites, comprising a udy, a private laboratory and an adjoining room r a professor's assistant are provided. Rooms for esearch students are provided adjacent to those for e professors, in order that student and teacher may ork in close cooperation.

Three lecture halls have been built in the Mallinckdt Laboratory, one seating 420, one 250 and a ird 90 students. To the rear of the lecture platrms there are preparation rooms where the experients and demonstrations for the lectures can be preared and assembled. Special overhead and undereath illumination is available on all the lecture sks, and the halls can be wholly darkened by black rtains which are operated electrically.

The departmental library occupies a large room on e first floor of the Converse Laboratory and a coresponding room directly underneath it in the baseent. These rooms and their equipment were given Mrs. Gould as a memorial to her husband, Fredick Saltonstall Gould, Harvard '75. They are anelled in antique oak and their furniture has been pecially designed.

The campaign for funds for the new laboratories as brought to a successful close in the spring of 926. The executive committee appointed by the orporation of Harvard College, with Bishop William awrence as chairman, and Dean Wallace B. Donham, the Graduate School of Business Administration, as ecutive chairman, was able to announce the receipt $2,000,000 toward the construction of the building and $1,000,000 for endowment. The firm of Coolidge, Shepley, Bulfinch and Abbott was selected as architects.

THE SOUTHWEST ARBORETUM OF THE BOYCE THOMPSON INSTITUTE FOR PLANT RESEARCH

Twelve hundred persons attended the dedication of the Boyce Thompson Southwest Arboretum at Superior, Arizona, sixty miles east of Phoenix, on April 6. The arboretum is at the base of the old Pickett Post Mountain and had an ideal setting for the dedication.

Boy Scouts of Superior acted as guides to the throngs visiting the institution, which was dedicated to the service of mankind. F. J. Crider is director of the arboretum. He is assisted by Fred Gibson and Palmer Stockwell.

The arboretum now has more than 3,000 specimens of plants, many of them native to the Southwest desert country. Hundreds of them have been imported from foreign countries. Through the study of these plants it is hoped to bring new products to Arizona soil.

This year some 600 new plants have been added to the gardens. Flora from the tropics and the Orient have been transplanted with the view of making them staple agricultural products of this section.

Giant tortoises imported from the Galapagos Islands attracted much attention from the visitors. The flower gardens, cactus gardens and the nursery also attracted attention. An interesting machine makes an autographic record day by day of the growth of the giant or Sahuari cactus. This machine shows that the cactus shrinks at a certain period each day.

Four Hopi Indians gave a number of their tribal dances at the luncheon hour and the University of Arizona band played during the afternoon.

Dr. William Crocker, director of the Boyce Thompson Institute for Plant Research at Yonkers, N. Y., presided in the absence of Mr. Boyce Thompson.

President Leroy Shantz, of the University of Arizona, and Professor William Trelease, of the University of Illinois, gave short addresses. Governor John C. Phillips, of Arizona, spoke in appreciation of the work of Mr. Thompson in establishing the arboretum.

THE FIFTH INTERNATIONAL BOTANICAL CONGRESS

The executive committee of the Fifth International Botanical Congress, of which Professor A. C. Seward, F. R. S., of the University of Cambridge, is president, requests that the following announcements should be made public:

Motions on the subject of nomenclature for consideration by the congress should be in the hand of the rapporteur général, Dr. John Briquet, before September 30, 1929.

Motions must be presented in the form of additional articles (or amendments) to the rules of 1905–1910, drawn up in the form adopted in the International Code, and must be drafted as briefly as possible in Latin, English, French, German or Italian. At least one hundred printed copies must be presented.

According to the decisions of the Brussels Congress, 1910, only motions relating to new points which were not settled in 1905 and 1910 can be presented. Motions which do not answer to these conditions shall only be discussed if the Cambridge Congress, 1930, decides to take them into consideration.

For further information about the program of work for nomenclature, apply to the rapporteur général, Dr. John Briquet, Conservatoire botanique, Geneva (Switzerland).

SYMPOSIA ON THEORETICAL PHYSICS AND CHEMICAL KINETICS

A SYMPOSIUM on theoretical physics will be conducted at the University of Michigan during the summer session of 1929, June 24 to August 16. The following physicists will participate:

- E. A. Milne, University of Oxford: "Problems in Astrophysics, and Vector and Tensor Methods in Statics and Dynamics."
- K. F. Herzfeld, the Johns Hopkins University: "Statistical Mechanics."
- Leon Brillouin, University of Paris: "Quantum Statistics."
- Edward Condon, Princeton University: "Introduction to Quantum Mechanics."
- P. A. M. Dirac, University of Cambridge: "Advanced Quantum Mechanics."
- D. M. Dennison, University of Michigan: "Band Spectra."

In addition to the lectures on the subjects announced, discussion groups will be organized for the consideration of special subjects and problems. These discussion groups will be conducted by the symposium lecturers. The privilege of attending the symposium and seminars, and of carrying on research in the laboratories and libraries of the university during the summer session will be extended to holders of the degree of doctor of philosophy or of doctor of science. Those desiring to avail themselves of this privilege should correspond with Professor H. M. Randall, director of the physical laboratories of the University of Michigan.

The School of Chemistry of the University of Minnesota announces a symposium on chemical kinetics to be held from July 29 to August 31 during the summer session. Professor H. S. Taylor, of Princeton University, and Professor M. Polanyi, of the Kaiser Wilhelm Institute, Berlin, will be in residence as guests. Professors S. C. Lind and R. S. Livingston, of the University of Minnesota, will also take part. Professor Taylor will lecture on "Catalysis and Photochemistry," Professor Polanyi on some phase of chemical activation, Professor Lind on "Chemical Activation by Ionizing Reagents" and Professor Livingston on "Chemical Kinetics in Solution."

SCIENTIFIC NOTES AND NEWS

THE medical faculty of the University of Munich has conferred the degree of M.D. *honoris causa* on Professor Graham Lusk, professor of physiology in the medical college of Cornell University.

THE Bruce medal of the Astronomical Society of the Pacific, recently awarded to Dr. Frank Schlesinger, director of the Yale Observatory, has been presented to him by Professor Ernest W. Brown at a meeting in the Lampson Lyceum at New Haven.

AT the recent General Assembly of the National Chemical Society of Poland in celebration of the tenth anniversary of its founding, Colonel Marston Taylor Bogert, professor of organic chemistry at Columbia University, was elected an honorary member.

DR. HEINRICH TIETZE, professor of mathematics, and Dr. Wilhelm Manchot, professor of organic chemistry, both of the University of Munich, have been elected members of the Bavarian Academy of Sciences. As corresponding members have been elected Dr. Otto Dimroth, professor of chemistry at Würzburg, and Dr. Wilhelm Meinardus, professor of geography at Göttingen.

CHARLES J. RHOADS, a Philadelphia banker, president of the Indian Rights Association, has been invited by Mr. Hoover to succeed Charles H. Burke, who resigned several weeks ago as head of the Indian Bureau.

MAJOR-GENERAL AMOS A. FRIES on March 28 completed his work as chief of the Chemical Warfare Service. He is succeeded by Colonel Harry L. Gilchrist, who has been given the rank of major-general.

PRESIDENT HOOVER has requested the Assistant Secretary of Agriculture in the previous administration, Renwick W. Dunlap, to continue in office. As assistant secretary, Mr. Dunlap has given special attention to the farms owned and operated by the department and to agricultural appropriation matters

and has been chairman of the building committee, in addition to the other duties connected with his office.

Fred W. Morrell has been appointed chief of the branch of public relations in the Forest Service, Evan W. Kelley has been appointed district forester in charge of the Northern National Forest District, and Joseph C. Kircher district forester in charge of the eastern district. As chief of the branch of public relations, Mr. Morrell will have charge of the work of state cooperation and of the informational activities of the Forest Service. He succeeds the late J. G. Peters, who died last October.

Dr. Edgar L. Hewett, director of the San Diego museum since its foundation, tendered his resignation from the active directorship to the Museum Association at its recent annual meeting and was appointed director emeritus. Lyman Bryson, lecturer in anthropology at the State Teachers College and extension lecturer for the University of California, who has been associate director for the past year, was elected director.

Professor Harry C. Fortner, of the University of Vermont, has been appointed assistant state ornithologist of Vermont.

Professor Mataro Nagayo, director of Institute of Infectious Diseases, Tokyo Imperial University, has succeeded Surgeon Admiral Tadao Honda, who died on December 13, as president of the Japanese Society of Cancer Research.

Dr. Knud Rasmussen, the Danish Arctic explorer, who is specially noted for his researches into Eskimo life and culture, is planning a new expedition, probably to start next year and going in the first instance to Alaska.

Professor E. Findlay Freundlich, astronomer of the Kaiser Wilhelm Institute at Potsdam, left Berlin in February as the head of an expedition of six members to observe the total eclipse of the sun on May 9 in the village of Takingeun in the mountains of Sumatra.

Dr. W. A. Noyes, of the University of Illinois, will make a lecture tour of the West during April and May, visiting a number of institutions and sections of the American Chemical Society. He will speak on "America's Opportunity in Chemistry," "International Relations," "The Electronic Interpretation of Oxidation and Reduction," and other subjects. This is the second of a series of lectures being planned for the Far West and is being arranged by Dr. J. L. St. John, head of the division of experiment station chemistry, of the State College of Washington, at Pullman.

Professor Anna Botsford Comstock, of Cornell University, has been appointed special lecturer for the nature camps of the Pennsylvania State College to be held from June 27 to July 18 and from July 17 to August 7. Mrs. Comstock will spend a week in each camp where she will give two lectures or nature readings each day.

Captain Donald B. MacMillan gave a lecture on April 9 before the Swarthmore Chapter of the Society of Sigma Xi entitled "Under the Northern Lights."

On March 26 the DeLamar lecture at the Johns Hopkins University School of Hygiene was given by Dr. Henry C. Sherman, Mitchill professor of chemistry in Columbia University, under the title "Food and Health."

The Graduate School of Brown University announces that Dr. Hans Zinsser, professor of bacteriology and immunity at the Harvard Medical School, has accepted an invitation to give the address at the Graduate School Convocation on June 15, 1929, when advanced degrees will be conferred.

Professor Arnold Sommerfeld, director of the institute for theoretical physics of the University of Munich, gave two lectures at the Ohio State University on April 4—one on "The Conduction of Electricity in Metals" and the other on "The Modern Aspect of the Theory of Atomic Structure."

Dr. Felix Bernstein, professor of mathematical statistics in the University of Göttingen, is working at the Cold Spring Harbor Biological Station.

Dr. F. K. Richtmyer, professor of physics at Cornell University, has been selected consulting editor of the International Series in Physics to be produced by the McGraw-Hill Book Company. Dean Dexter S. Kimball, dean of the college of engineering, is the consulting editor for the Industrial Management Series.

Dr. F. V. Coville, principal botanist, and H. T. Edwards, senior technologist in fiber plant investigations, of the Bureau of Plant Industry, are delegates to the fourth Pan-Pacific Science Congress to be held at Batavia and Bandoeng, Java, from May 16 to 23. Dr. R. D. Rands and George Arceneaux, specialists in sugar-cane diseases, will attend the third Congress of International Sugar-Cane Technologists at Soerabaja, Java, from June 7 to 21. *En route* from San Francisco, Dr. Coville will visit Japan to make some studies of acid soil plants. Mr. Edwards will visit the Philippines where he has spent many years in the study of abaca, maguay and other long-fiber plants.

DR. J. E. GUBERLET, of the department of zoology of the University of Washington, has returned to Seattle after a six months' leave spent in travel and research. During the month of December he attended the International Congress on Tropical Medicine and Hygiene at Cairo as one of the six delegates from American universities.

DR. FREDERICK L. HOFFMAN, consulting statistician of the Prudential Insurance Company and director of the Research of Aviation Business Bureau, Inc., will make an extended trip over the line of the Pan-American Airways at present in operation for passenger purposes. On April 20 he will fly from Miami to Havana and Santiago, Cuba, continuing to Port-au-Prince, Haiti, and terminating his trip at San Juan, Porto Rico. Returning by air to Miami, he will fly across to Nassau, Bahamas. Dr. Hoffman has flown more than 20,000 miles in this country, Canada and Europe. His chief interest is in the ascertainment of dependable facts concerning safety factors affecting all kinds of flying operations.

DR. VICTOR COFMAN will leave the Experimental Station of the du Pont Company at the end of this month. He is going for an extensive tour around the world and plans to visit various universities in Europe and elsewhere and to investigate the trend in physico-chemical and biophysical research. His address in Europe will be care of Dr. J. Cofman-Nicoresti, 18 Lord Roberts Avenue, Leigh-on-Sea, Essex, England.

DR. LESLIE SPIER, of the University of Oklahoma, will make an ethnological survey of the Gilbert and Ellice Island groups in Micronesia for the Bishop Museum of Honolulu. Dr. Spier will sail from San Francisco early in August for a year in the field.

A BRONZE tablet in honor of Josiah Hornblower, who in 1753 brought from England and set up the first steam engine in this country, will be unveiled on April 24 when the American members of the Newcomen Society of England will visit his grave at Belleville, N. J. The Newcomen Society, organized for the study of the history of engineering and technology, will hold its fifth American meeting in New York following the dedication of the tablet.

DR. JOHN MASON TYLER, professor emeritus of biology at Amherst College, died on April 12 at the age of seventy-eight years.

STEWART CULIN, curator of ethnology in the Museum of the Brooklyn Institute, died on April 8 in his seventy-first year.

COLONEL E. LESTER JONES, director of the United States Coast and Geodetic Survey for the last fourteen years, died on April 10 at the age of fifty-three years.

THE deaths are announced of Dr. Theodor Posner, professor of physics at Greifswald; of Dr. William Küster, professor of organic and pharmaceutical chemistry at Stuttgart; of Dr. Otto Jaekel, emeritus professor of geology and paleontology at Greifswald; of Dr. August Pütter, professor of physiology at Greifswald, and of Dr. Erasmus Kittler, professor of electrotechnics at Darmstadt.

THE will of the late Dr. Jonathan Dwight divides his collection of more than 60,000 North American birds' nests, eggs and skins between the American Museum of Natural History and the City Library Association of Springfield, Massachusetts.

THE herbarium and library of the late Dr. Bruce Fink have been acquired by the University Herbarium of the University of Michigan. The collection of lichens is the source material on which Dr. Fink's forthcoming book, "Lichens of the United States," has been based. The materials will be transferred from Miami University in June and will be accessible within a few months thereafter.

PROFESSOR ALEXANDER SILVERMAN has offered a membership in the American Chemical Society each year to the candidate for the bachelor of science degree in chemistry in the Department of Chemistry of the University of Pittsburgh who has the best scholastic record for the first three years.

THE American Pharmaceutical Association has available a sum amounting to $750 which will be expended for the encouragement of research. Investigators desiring financial aid in their work will communicate before June 1 with H. V. Arny, chairman, A. Ph. A. Research Committee, 115 West 68th St., New York, N. Y., giving their past record and outlining the particular line of work for which the grant is desired.

THE fellowship in electrochemistry recently established by Dr. Edward Weston, of Newark, will be assigned for the first time July 1, 1929, to apply to the fall and spring terms of 1929–30. The fellowship amounts to $1,000 and is awarded without distinction on account of sex, citizenship, race, or residence. The applicant must be under thirty years of age at the time of the award. All those interested should apply at once to the secretary of the American Electrochemical Society, Columbia University, New York City, for copy of the printed application form.

DR. WILLARD ROUSE JILLSON, state geologist, announces that the Kentucky Geological Survey, which

was established in Frankfort in 1854 with Dr. David Dale Owen as its principal geologist, will celebrate this year its seventy-fifth anniversary.

The U. S. Civil Service Commission states that the position of chief engineer, Metallurgical Division, Bureau of Mines, Department of Commerce, is vacant and that in view of the importance of this position in the field of metallurgical research the method of competition will be as follows: Instead of the usual form of civil service examination, the qualifications of candidates will be passed upon by a special board of examiners, composed of Dr. A. C. Fieldner, Chief Engineer, Experiment Stations Division, Bureau of Mines; Dr. F. G. Cottrell, Chief of Fixed Nitrogen Research Laboratory, Department of Agriculture; Zay Jeffries, Consultant, Aluminum Company of America and General Electric Company; Dr. John Johnston, Director of the Department of Research and Technology, U. S. Steel Corporation, and Dr. A. S. Ernest, Examiner of the United States Civil Service Commission, who will act as chairman of the committee. For the purposes of this examination, all of these men will be examiners of the Civil Service Commission. The entrance salary is $5,600 a year. Formal applications will be received by the Civil Service Commission until May 8.

The committee appointed by the executive committee of the American Section of the Society of Chemical Industry to promote attendance and to make arrangements for transportation in connection with the annual general meeting is sending to the American and Canadian members of the society the following message from President Arthur D. Little: "The annual meeting of the society in Manchester, England, during the week of July 8 affords an opportunity, of which it is hoped many may take advantage, to consolidate the friendships so happily begun at our meetings of last year and to establish many new ones under peculiarly favorable auspices. As it is my pleasant duty to preside at the Manchester meetings I earnestly hope that I may have the support of many of you, and a goodly representation from this side will be regarded as a compliment to our British friends. Those of you who have enjoyed the gracious charm of English hospitality will need no urging to bring you under its influence again; to those of you who have not done so the Manchester meeting provides an opportunity which I hope none of you who can arrange to take the trip will fail to utilize. Mrs. Little and I are sailing on the *Homeric*, June 15, and it would give us especial pleasure to be accompanied by as many of the members and friends of the society as can make it convenient to sail upon that date."

M. Lahy writes that the Sixth International Congress of Technopsychology (Association Internationale des Conferences de Psychotechnique) will convene in Barcelona beginning October 5, 1929. Three of the leading topics to be discussed are: (1) Critique of tests proposed for study of industrial fatigue. (2) Minimum statistical measures necessary for standardization and validation of a psychotechnical test. (3) Psychotechnical methods to be used in studying personality. The Barcelona World's Fair will probably help in bringing to this congress a representative group of technopsychologists from many countries. Those who wish to secure invitations to the congress should write to Dr. W. V. Bingham, 29 West 39th Street, New York, N. Y.

The present year being the jubilee year of Pope Pius XI, the Pontifical Academy of Sciences (Nuovi Lincei) has decided to offer a prize of 10,000 lire, to be awarded for the best critical dissertation on the physical theory of quanta. The prize is open to all except the ordinary members of the academy, and dissertations, which must be unpublished, are to be submitted before October 31 next. Three typewritten copies, in either Latin, Italian, French, English, German or Spanish, must be supplied.

On recommendation and vote of the advisory committee of the American Medical Association it is stated in the *Journal* that last year the Committee on Scientific Exhibit has again authorized an exhibit and demonstration of various clinical laboratory methods of a biochemical nature which are used for diagnostic purposes for the coming Portland meeting of the association. The first group will include the routine tests which every physician may undertake in his own office; the second group will deal chiefly with the chemical blood determinations which have come into wide clinical use; the third group will take up methods primarily of a research character. Demonstrations of the different methods will be given on a definite schedule each day. The exhibit will be under the active charge of Dr. V. C. Myers, professor of biochemistry, Western Reserve University School of Medicine, with the collaboration of Dr. Howard D. Haskins, professor of biochemistry, University of Oregon Medical School; Dr. John A. Killian, professor of biochemistry, New York Post-Graduate Medical School and Hospital; Dr. Joseph H. Roe, professor of chemistry, George Washington University School of Medicine; Dr. Edwin E. Osgood, assistant professor of biochemistry and medicine, University of Oregon Medical School, and Dr. Earl R. Norris, assistant professor of chemistry, University of Washington.

Two forestry bills are being considered by the legislature of New York State. One of these amends the conservation law to give the state power to purchase large areas of non-agricultural lands, suitable for forest growth, outside of the forest preserve, for reforestation purposes. The other bill provides for the acquisition by counties within their boundaries of such tracts of less than 500 acres, the state to contribute to such purchases a share equal to that contributed by the county, but not in excess of $5,000 for any county in any one year. The state, under the terms of this latter bill, would also supply the trees to the counties. All the work would be under the supervision of the State Department of Conservation.

At the annual meeting of the New York Zoological Society the following resolutions were passed:

Whereas, One of the primary objects of the New York Zoological Society is the preservation of our native American animals; and

Whereas, The indiscriminate killing of predatory animals without a thorough study of their value in any given area is unscientific and unfair; and

Whereas, The introduction of exotic species may become a dangerous factor in disturbing the balance and natural condition of our native American game; therefore, be it

Resolved, That the New York Zoological Society, while recognizing the fact that a certain control of predatory animals is at times necessary, is strongly opposed to the extermination of any single species of our American wild life; and, be it further

Resolved, That the federal government be urged to adopt for our National Parks a policy whereby all the wild life should be studied intensively with a view to determine scientifically to what extent its regulation is advisable, and that the policy of destroying the predatory animals be suspended until such policy has been considered, and that this society tender its services to the national government for the purpose of aiding in the efforts to reach a proper decision; and, be it further

Resolved, That the New York Zoological Society strongly opposes the introduction of non-native animals into our National Parks and urges the National Parks service to prohibit all such introductions.

The ninth annual report of the Council of the Institute of Agricultural Botany, as abstracted in the London *Times*, describes improvements made during the year ended September 30, 1928, in the council's property at Cambridge, and mentions that the vast part of the trial ground, which was taken over in a very dirty state in 1927, was so well cleaned that it bore creditable crops of cereals in 1928. The problem of growing so many varieties of cereals year by year on a small area can only be solved, the report points out, by the adoption of an unusual rotation, but the size of the yields and the quality of the grain grown on the trial ground in recent years bear witness to its success. During the season the station tested 26,583 "routine samples" and 3,410 "investigational samples," an increase of 14 per cent. on the previous year's tests. The report adds: "The bad harvest of 1927 introduced considerable difficulties into the testing of most kinds of seeds, and in cereals it led to a more general recognition of the fact that germination tests demand greater skill than is commonly believed. Though these factors all added to the work of the station and involved a large body of routine investigations, the tests were made and reports issued without any falling away from the standard of rapidity and accuracy for which the station has now an established reputation."

The Brussels correspondent of the *Journal* of the American Medical Association reports that in beginning his course in pathologic anatomy at the new institutes of the Faculté de médecine in Brussels, Professor Dustin expressed himself somewhat as follows: "During the war, two members of our faculty (Drs. Depage and Sand) traveled in the United States, and on their visit noted many evidences of the sympathetic interest that the people manifested in our country. We knew therefore that we could count on generous aid from that source. But the Americans have given their aid to other nations besides ourselves, and if they have aided Belgium in a particular way, it is because they had a high appreciation of the great part that Belgium played during the great struggle. The Rockefeller Foundation bestowed on the University of Brussels some of its largest gifts because the university is liberal and not controlled by any philosophical or religious tendencies. Another thing that contributed greatly to dispose the Americans in our favor was what we accomplished during the war; notably, the model hospital (the ambulance from the ocean to La Panne) and its scientific laboratories, which carried on its work for four years within a few kilometers of the front line trenches. It was the quality of work performed there that brought the Belgian investigators to their attention. Do not forget, ladies and gentlemen, that if, at the close of your studies, you leave this, our university, technically and morally equipped to perform in an outstanding manner the professional tasks that await you, it is in great part due to the aid given by the Rockefeller Foundation."

UNIVERSITY AND EDUCATIONAL NOTES

Edward S. Harkness has given to Columbia University $2,000,000 for the erection of a residence hall near the new medical center on Washington Heights, for medical students and junior unmarried hospital officers.

By the will of Mrs. Katie M. A. Grimmons, of Somerville, Massachusetts, provision is made for the creation of a $150,000 trust fund, the income to be used for scholarships to be given to students at Massachusetts Institute of Technology.

Julius Rosenwald, of Chicago, has given $250,000 toward the endowment fund of the American University of Beirut, Syria.

The contest in the courts of the will of the late W. J. McDonald, of Paris, Texas, who left in 1926 almost his entire estate to found an astronomical observatory in connection with the University of Texas, has been settled by a compromise. In place of the $1,200,000 originally bequeathed, a little less than $900,000 is secured to the observatory by the compromise. The Board of Regents of the university has full power to use this fund at once or later to advance astronomical knowledge in any way that they may deem wise. It being known that Mr. McDonald at times contemplated the accumulation of the fund over a number of years before the actual establishment of the observatory, the regents will proceed with plans very slowly and in accordance with advice from leading astronomers.

The University of Chicago announces the appointment of Dr. Russell M. Wilder, of the Mayo Clinic, Rochester, Minnesota, as professor and chairman of the department of medicine, to succeed, as chairman, Dr. Franklin C. McLean, whose appointment as director of university clinics was recently announced.

The Vanderbilt University School of Medicine, Nashville, Tennessee, announces the appointment of Dr. William Groce Harrison, of Birmingham, Alabama, as lecturer in the history of medicine. Dr. Harrison will begin his work in September.

Dr. John Arthur Thomson, regius professor of natural history at the University of Aberdeen, will join the staff of the University of California at Los Angeles next year as visiting professor of biology.

DISCUSSION AND CORRESPONDENCE

IS LIFE QUANTITY?

It is, answers Mrs. Augusta Gaskell. Her answer is based on atomic physics, although she is not an experimental physicist. She is, however, a broad and careful reader in that field. This is attested both by her book, "What is Life?" and by the distinguished physicist, K. T. Compton, who introduces her.

Nor is she an experimental biologist although likewise an extensive reader in parts of that field. Furthermore, her answer has a tentative backing from this side also by the distinguished biologist, Raymond Pearl.

Surely then her answer deserves serious consideration, for she and her introducers, like everybody else, recognize it to be an answer to a question than which no other concerns human kind more deeply.

That which entitles this answer above the hundreds of others the question has received to the attention of scientists is the claim by the author and her technical sponsors that here at last is an answer susceptible of being tested by laboratory experiments.

I venture the opinion that not only can this new answer not be really tested, thus, but that were it objectively true no answer to any scientific question could be so tested.

This sweeping rejection of the hypothesis that life is quantity is based on the recognition that the assumption that quantity *alone* can constitute and can explain any natural phenomenon is an assumption which would place that phenomenon outside the realm of human knowledge.

All natural knowledge whether gained inside or outside of the laboratory necessarily involves observation. This is granted as an idea and adhered to in practice by experimentalists without exception.

Likewise it is both ideationally and practically granted that at least three parts of the human organism are directly and indispensably involved in experimental work. These are hands, eyes and brain.

From these facts it certainly follows, though apparently obscurely for many workers, that all human knowledge is directly and inseparably tied to two classes of psychobiological phenomena. These are sense perception and ideation.

But now comes a proposition which though demonstrably true, I believe, is far from generally granted or recognized as possibly true. It is that quantity and quality are so linked together and interpenetrated in the make-up of natural bodies, and consequently in our knowledge of them, that neither can be conceived (except in pure fancy) to exist apart from the other.

The cosmic order, ourselves and everything else being included, is such as to compel our recognition sooner or later that quality and quantity form a continuum similar, so far as inseparableness is concerned, to the space-time continuum of Einsteinean relativity.

The road of justification for this statement is long, steep and stony, but yet "passable though dangerous" as highway signs often read.

It is blazed, inadequately, in "The Organismal Conception"[1] and can not be traveled at all here. One

[1] Ritter and Bailey, Univ. of Calif. Publ. Zool., Vol. 31, No. 14, pp. 307–358, 1928.

point may, however, be appropriately referred to, dealing as this note does with a theory grown from the rich soil of atomic physics. No working physicist ever, so far as I know, thinks for a moment of his science as able to get along without human eyes and human hands.

Not many words occur oftener or in more crucial connections in many technical treatises than *observer*. Yet the fact that this term implies a whole raft of objects—bones, muscles, nerves, sense organs, glands, blood vessels, and so on, all so united and interrelated as to become a *sine qua non* of the observations and concepts which are the sum and substance of the discussions—these indubitable facts seem to be quite ignored so far as the discussions themselves are concerned.

Typically, it almost seems, "the observer" is reduced to a mathematical point much as stars and other heavenly bodies are for quantitative treatments of them.

It is, I think, fortunate that we are given this book on the ancient question, "What is Life?" at this particular time and in this particular form. It is fortunate because the discussion shows more unmistakably than anything I have seen that the issue raised by the book goes to the heart of one of the profoundest problems mankind has ever grappled with.

That issue is the universal struggle between the naturalistic and the supernaturalistic ways of observing and thinking about the world in which we live.

A special merit of the discussion is its appropriateness as a stimulus to discriminating sharply between these two ways of observing and thinking. Just so far as the proper balance is held between quantity and quality in the knowledge processes are these naturalistic. Indeed such balance is exactly a basic constituent of what "the natural" really is. Per contra just so far as there is departure from such balance does super- or extra-naturalism prevail. From this it follows that supernaturalism takes on almost as many and varied forms as does naturalism.

A reference that is peculiarly revealing in this connection is given by Mrs. Gaskell.[2] She quotes from R. A. Millikan:

> Indeed, from my point of view of that ancient philosopher, the problem of all natural philosophy is to drive out qualitative conceptions and to replace them by quantitative relations. And this point of view has been emphasized by the far-seeing throughout all the history of physics clear down to the present.

The ancient philosopher alluded to was Pythagoras. That both Professor Millikan and Mrs. Gaskell should fail to perceive that to "drive out qualitative conceptions" from "all natural philosophy" would be to drive sense data out of natural philosophy and so relieve students from the necessity of making observations, is perhaps not surprising, for the point involves complex and recondite knowledge in the realm of psychobiology.

But it does seem a bit strange that painstaking students having acquaintance enough with the history of science to refer to Pythagoras at all should not take cognizance of the direction in which this reference faces them. No adequate history of philosophy fails to tell in considerable fulness the story of the "Pythagorean mysteries" as these flourished during several centuries of classical antiquity. The pairs of opposites, odd and even, and male and female, for example, corresponding in number to the sacred ten, show what wonders can be accomplished on Pythagorean principles. And the neo-Pythagoreanism of still later times shows still greater possibilities in this direction.

Nor do these stories fail to make clear that these old confusing and corroding futilities (as we now see them) arose primarily from this very effort to "drive qualitative conceptions" from the world; or at least to reduce them to the rank of mere copies or imitations of pure number. Much to the point for this new (supposedly) hypothesis of the nature of life are a couple of sentences in Windelband's discussion of ideas about the microcosm and the macrocosm that had vogue during the Renaissance:

> The book of Nature is written in numbers; the harmony of things is that of the number-system. All is arranged by God according to measure and number; *all life is an unfolding of mathematical relations.*[3]

My italicizing of the last phrase is probably superfluous for calling attention to its relevancy to the hypothesis under examination.

Mrs. Gaskell is sufficiently explicit in crucial places to leave no room for doubt about the essence of her theory. A new and unique kind of unit is assumed to arise from a "unique manner of combination of ultimate units" already known, namely, electrons and protons. This new kind of unit, or system, is the "Z System." What constitutes the newness of this system is its possession of "unique qualities." Now notice: "The degree to which these unique qualities are present, of course, is determined quantitatively."[4]

The reasoning that would justify this conclusion (supposing justification possible) is disposed of by that mischief-making little phrase "of course." What the logical leap here really covers can not be even

[2] "What is Life?" p. 32.

[3] "A History of Philosophy" (Eng. by J. H. Tufts), 2d ed., p. 372.

[4] "What is Life?" p. 134.

pointed toward in this note. But if my view about the quantity-quality continuum is correct, that of itself disposes of the conclusion.

The sum and substance of my criticism is that Mrs. Gaskell's argument is a garment beautifully woven and patterned from ultra-modern materials (atomic physics) and draped upon a manikin of supernaturalism that is at least as old as the Pythagorean mysteries. Nor is there difficulty about so classifying this manikin as to bring out its kinship with others much more recent and, to biologists, much more familiar than its Pythagorean prototype. It will suffice to mention the Pangens of Darwin and the Determinants of Weismann. For these, each in its day, illumined the whole biological sky from horizon to zenith. Any biologist of forty years' standing will be able to enlarge the class to his heart's content.

Or if one's predilections whet his curiosity more toward the physical than the biological descendants of the Pythagorean system and precursors of Gaskellean system, the monads of Leibnitz modernized from those of Bruno should satisfy that curiosity. In fact the peculiar interiorness, so to speak, of Mrs. Gaskell's new unit is strangely reminiscent of Leibnitz's monad as a "purely internal principle." Mrs. Gaskell tells us, it should be noted, that the only space available for the new unit is "intraatomic space."[5]

There are two possibilities of real benefit from studying the ancestral line of units of this kind. One is in the chance afforded for seeing the particular ways in which the principle of quality-quantity can be violated. The other is in illustrations they furnish of the statement previously made that the super- or extra-natural can manifest itself in almost as great variety as the natural.

As I see the new theory it is only one more illustration of the self-defeat to which the imperialistic claims of atomism are bound to lead if pushed into the realm of mental life. And perhaps in this as in so many other situations self-defeat is the most effective kind of defeat and hence in a sense the surest promoter of truth.

Should the book before us contribute even in this negative way to the deliverance of mankind from bondage to all forms of supernaturalism, it would have rendered a great service. For all aspects of man's spiritual life—those to which are due his science, his philosophy, his ethics, his art, his religion, and all the rest—are subject in greater or lesser measure to this bondage.

WILLIAM E. RITTER

UNIVERSITY OF CALIFORNIA,
March 7, 1929.

[5] p. 128.

HERMAPHRODITISM IN ARBACIA

HERMAPHRODITIC sea-urchins are rare. One has been reported from Africa; two from Europe. That is all, or at any rate all I have been able to find in a hasty search of the literature.

Viguier in 1900[1] makes brief mention of a hermaphroditic specimen of *Sphaerechinus granularis* collected at Algiers. He gives no details. Herlant, 1918,[2] describes a *Paracentrotus lividus* from Villefranche with three large testes, one atrophied testis and one mixed gonad. Drzewina and Bohn, 1924,[3] report a *Strongylocentrotus* (= *Paracentrotus*) *lividus* with four ovaries and one testis. This was taken at Roscoff. In all three of the above cases, self-fertilization was possible; and in the last two, normal larvae were obtained.

In spite of the many thousands of *Arbacia* used at Woods Hole, there is apparently no record of hermaphroditism in this form. On June 25, 1928, at Woods Hole, I found an *Arbacia punctulata* with four typically red ovaries and one ovotestis. The ovotestis consisted of a red ovarian portion with normal ova, and a yellow testicular portion with normal spermatozoa. On finding this hermaphroditic sea-urchin, I was reminded of an earlier discovery of the same sort. In the summer of 1915, while working at Woods Hole, I came across a specimen of *Arbacia* with two testes, two ovaries and one ovotestis. The ovaries and testes were alternately placed, that is to say, neither the two ovaries nor the two testes were adjacent to each other. In this case, as in the one previously mentioned, the eggs and sperm were normal and gave rise to normal larvae following self-fertilization.

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MICROPHOTOGRAPH OR PHOTOMICROGRAPH?

AFTER observing for several times in close succession what seems to me to be inconsistent use of these terms, I am moved to register my views on the subject. A microphotograph is logically, and by derivation, "a microscopic photograph of a macroscopic object" (Century dictionary). The man who claims to have originated the term meant it to be used in this sense only. A photomicrograph is "a macro-

[1] Viguier, 1900, *Compt. Rend.*, Acad. Sci. Paris, 131: 63.

[2] Herlant, 1918, "Notes et Revue," *Arch. de Zool. exp. et gen.*, 57: 28.

[3] Drzewina and Bohn, 1924, *Compt. Rend.*, Acad. Sci. Paris, 178: 663.

scopic photograph of a microscopic object." Funk and Wagnalls dictionary says, "Photomicrography is the art or process of making photomicrographs: opposed to microphotography."

Webster and Oxford give definitions for the two terms similar to those above quoted, but, unfortunately, give the other word as a second choice in both cases. Oxford, however, quotes Sutton and Dawson, "Dictionary of Photography," "Microphotography . . . is now used to designate the reduction of negatives to very minute size, and serves to distinguish it from the process denominated photomicrography."

Obviously to me, "photomicrographs" is the correct term to use for the numerous reproductions appearing in current scientific literature and advertisements, of all manner of photographs taken through microscopes. I deplore such misuse as is evidenced in the *Scientific Monthly,* September, 1928, page 209 (the same article uses the term "microorganism"); in SCIENCE, advertisements in various 1928 numbers; in *Industrial and Engineering Chemistry,* volume 20, number 10, advertisement on page 62; and in other places, the exact references to which I have forgotten. In the *Scientific Monthly* referred to, the misuse of "micro" as a prefix is carried to "microcinematographic photographs." May I mention a paper by R. B. Harvey and myself (*Phytopathology,* volume 11, number 3) in which the perfectly good and logical, though somewhat long word, "cinematophotomicrography," is used?

It would seem that "custom" has already permitted the misusage indicated. I protest. I wonder if it will do any good.

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WHEN IS NORMAL NORMAL?

MUCH has been written about the concept of normality, especially in statistical and educational literature, but the terms "normal" and "abnormal" are commonly used both in those fields and in general biological terminology to denote approach to or deviation from the usual or average, without qualification as to whether they refer to the medium considered or to the causative factors involved. For this reason entirely normal reactors are frequently described as "abnormal," when in reality only the causative factors deviate from the average, and contrariwise abnormal reactors are described as "normal" because they have not shown "normal" responses to abnormal conditions.

Examples of this could be taken from almost any field of biology, but consider the case of an originally normal child whose experiences have caused it to develop certain inhibitions and behave quite differently from other children. In such a case the deviation of this child's behavior from the average behavior of children of his class is accepted as a measure of his abnormality. Suppose, though, that practically all average children when subjected to the same or similar experiences react in the same or in a similar manner. Then this child and his behavior are entirely normal when considered in the light of his past experiences, and it is only his experiences which are abnormal. Furthermore, if this child remained unaffected by the abnormal conditions he had experienced and which it had been shown would bring about a new type of behavior with average children, then, though still behaving like normal children without the same experiential background, he would be abnormal because he had not been normally affected by his unusual environment.

The same principle applies equally well, it seems to me, whether the unusual growth or other function of a tissue or organism or any other similar biological phenomenon is being considered. The medium itself may be abnormal and demonstrate appropriate abnormal behavior; again it may be entirely normal but attract attention by its response to abnormal causative factors.

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SCIENTIFIC BOOKS

Scientific papers of William Bateson. Edited by R. C. PUNNETT. 2 vols. Illustrated. The Macmillan Co., N. Y.

THESE two beautifully printed volumes from the Cambridge (England) University Press contain the collected scientific papers of Bateson reprinted from various journals and books. An account of his life and work by Mrs. Bateson and his more popular writings have already been published elsewhere. These volumes contain the record of his work, as he published it from time to time, conveniently brought together in one place. Like all "collected papers," many of these have now only a historical value. They have had their effect on contemporaneous scientific thought and investigation and are chiefly valuable now for the unified picture which they present of the achievements of one of the leading scientists of our time. To a student of the history of biological science in one of its periods of most rapid progress they will be of great value.

In order to understand what these papers are about and why they were written, one should have

his mind's eye the scientific background against hich they were projected. Of the two volumes, the rst belongs to the pre-Mendelian period in which e nature and causes of variation were Bateson's bjective; in the second volume, heredity in the light f Mendel's principles is the objective.

The earliest paper in these volumes dates from 886. At that time Darwin's evolution theory had een generally accepted by scientists. It was coneded that different groups of animals had diverged rom each other in the process of descent from a comnon ancestor, and efforts were being made to trace hese lines of descent. Bateson's paper deals with he ancestry of the Chordata, which by arguments based on comparative morphology and embryology hen much in vogue he seeks to connect with the imperfectly known group of the enteropneusta as represented in Balanoglossus. Bateson himself in common with biologists generally came later to place less confidence in theoretical lines of descent based on morphological and embryological resemblances. This study interested him in the subject of serially repeated parts, so conspicuous in the organization of chordates, a subject which comes in for more intensive and extended study in his book of 1894, "Materials for the Study of Variation."

Bateson next took up the study of variations in the form and texture of the shell of a mollusk, *Cardium edule*, "apparently correlated to the conditions of life" (1889). This investigation led to extensive travels in quest of material in the district of the Aral Sea and in Egypt. He finds by a study of shells from successive terraces of the Aral Sea that increasing salinity of the water is attended by marked changes in the character of the shell and concludes cautiously that these changes are probably a direct consequence of changes in the environment. But this does not lead him to adopt a Lamarckian explanation of evolution in general. He recognizes even in his shells the probably simultaneous action of environment and natural selection in producing racial changes. A variety of minor investigations upon the sense organs and perceptions of marine animals next engages Bateson's attention. These are recorded in the *Journal* of the Marine Biological Association in 1890. In the same year he publishes a paper on some cases of abnormal repetition of parts in crustacea and fishes, the same general subject which had been taken up in his first paper (1886) and which was to receive more extended treatment later. In the following year (1891) Bateson makes a study of "variations in floral symmetry of certain plants having irregular corollas." The underlying idea in his studies of variation throughout this period is expressed in this sentence:

> In proportion as the process of evolution shall be found to be discontinuous the necessity for supposing each structure to have been gradually modeled under the influence of natural selection is lessened, and a way is suggested in which it may be possible to escape from one cardinal difficulty in the comprehension of evolution by natural selection.

For his next subject (1892) in the study of variation, Bateson turns to insects, and investigates the relation between color of the cocoon in certain moths and that of the substratum, concerning which Poulton had described a protective resemblance. He was able to show that no such relation exists and that consequently protective resemblances as a factor in natural selection had probably been overestimated in Poulton's writings. But in the case of the color of larvae of the pepper moth (*Amphidasys betularia*) he verified the observations of Poulton that a protective resemblance to the environment does exist.

In the same year (1892) he published a paper on numerical variation in teeth, one of the parts of a projected general work on variation. As an outgrowth of this study he proposes a modification in the current idea of homology.

> The received view of homology supposes that a varying form is derived from the normal much as a man might make a wax model of the variety from a wax model of the type, by small additions to and subtractions from, the several parts. . . . But the natural process differs in one great essential from this. For in nature the body of the varying form has never *been* the body of its parent . . . but in each case the body of the offspring is made again from the beginning, just as if the wax model had gone back into the melting-pot before the new model was begun.

Another paper of this period (1892) describes some cases of variation in secondary sexual characters of insects, which statistically treated is thought to be dimorphic or polymorphic. The only one of these cases which in the light of our present knowledge would seem to be beyond question is that of the earwig (Forficula) with "low males" and "high males," which are of very different body-size and proportions, in particular with a striking difference in the length of the anal forceps. These differences have, however, since been shown in all probability to be a consequence of the intestinal fauna and flora of the insect, rather than of its genetic characteristics.

In two letters to *Nature* he attacks successfully some supposed cases of "aggressive mimicry" between flies and bumblebees. This is an incident merely in the general assault which he was preparing on the orthodox view of evolution as operating on continuous variation

subjected to the uninterrupted action of natural selection.

The year 1894 saw this general offensive launched in the extensive work now out of print, "Materials for the Study of Variation." The preface and introduction of this book are reprinted, which suffice to show the motive, methods and major conclusions of Bateson's work up to this time.

He recognizes the futility of mere speculation as to the course of evolution such as he himself regretfully adopted in his paper on the ancestry of the Chordata. He is *through* with all such methods.

To collect and codify the facts of variation is, I submit, the first duty of the naturalist. This work should be undertaken if only to rid our science of the excessive burden of contradictory assumptions by which it is now oppressed. Whatever be our views of descent variation is the common basis of them all. As the first step towards the systematic study of variation we need a compact catalogue of the known facts.

Such a catalog Bateson attempts to supply in the body of his work. The last page of Bateson's preface is worth quoting entire since it applies with added emphasis to the study of problems of evolution and to discussions of evolution which are carried on in our own time by methods so varied and with conclusions so contradictory.

The work was, as I have said, begun in the earnest hope that some may be led thereby to follow the serious study of Variation, and so make sure a base for the attack on the problem of Evolution. Those who reject the particular inferences, positive and negative, here drawn from that study, must not in haste reject the method, for that is right beyond all question.

That the first result of the study is to bring confusion and vagueness into places where we had believed order established may to some be disappointing, but it is best we deceive ourselves no longer. That the problems of Natural History are not easy but very hard is a platitude in everybody's mouth. Yet in these days there are many who do not fear to speak of these things with certainty, with an ease and an assurance that in far simpler problems of chemistry or of physics would not be endured. For men of this stamp to solve the difficulties may be easy, but to feel difficulties is hard. Though the problem is all unsolved and the old questions stand unanswered, there are those who have taken on themselves the responsibility of giving to the ignorant, as a gospel, in the name of Science, the rough guesses of yesterday that tomorrow should forget. Truly they have put a sword in the hand of a child.

If the Study of Variation can serve no other end it may make us remember that we are still at the beginning, that the complexity of the problem of Specific Difference is hardly less now than it was when Darwin first showed that Natural History is a problem and no vain riddle.

On the first page I have set in all reverence the most solemn enunciation of that problem that our language knows. [All flesh is not the same flesh: but there is one kind of flesh of men, another flesh of beasts, another of fishes, and another of birds.] The priest and the poet have tried to solve it, each in his turn, and have failed. If the naturalist is to succeed he must go very slowly, making good each step. He must be content to work with the simplest cases, getting from them such truths as he can, learning to value partial truth though he cheat no one into mistaking it for absolute or universal truth; remembering the greatness of his calling, and taking heed that after him will come Time, that "author of authors," whose inseparable property it is ever more and more to discover the truth, who will not be deprived of his due.

The underlying thought in Bateson's introduction is that specific groups are discontinuous whereas the environment is continuous. He suspects that variations which lead to the formation of species are discontinuous in nature, and catalogs in the body of his book evidence pointing in this direction. Galton had expressed a similar view, though his major attention had been given to the study of continuous variation, and after his death the Galton Laboratory had given exclusive attention to variation of this sort with the idea that it alone was responsible for evolution. Bateson says (p. 235):

To sum up, the first question which the study of variation may be expected to answer relates to the origin of that discontinuity of which species is the objective expression. Such discontinuity is not in the environment; may it not, then, be in the living thing itself?

The study of variation thus offers a means whereby we may hope to see the processes of evolution. We know much of what these processes *may* be. The deductive method has been tried with what success we know. It is time now to try if these things can not be seen as they are, and this is what variation may show us. In variation we look to see evolution rolling out before our eyes. In this we may fail wholly and must fail largely, but it is still the best chance left.

The consensus of biological opinion thirty-five years after the publication of Bateson's book would probably be that his effort had "failed largely," as he anticipated that it would, but that it had important consequences in leading to a fact-finding rather than a speculative study of evolution. Six years later De Vries began the publication of his mutation theory, Mendel's law was rediscovered, and a few years later still Johannsen's pure line and genotype concepts were made public, all being attempts to discover what the facts were about evolution as observed in progress at a particular time and place.

In the meantime Bateson himself was busy with the study of new cases of discontinuity in variation

such as the color variation of flat-fishes (1894), of Chrysomelid beetles (1895), of webbed feet in Antwerp pigeons (1896), of meristic variation in crustacea (1900) and of melanism in moths (1900). And his studies are extended to successive generations so as to cover the inheritance of variations. He writes a general article for *Science Progress* (1897) on "Progress in the Study of Variation" [including heredity]. He had published in 1895 an investigation of the origin of the cultivated cineraria, which he shows to have been through hybridization of several wild species. In 1900 he discusses the inheritance of variation in the corolla of *Veronica Buxbaumii.* Two controversial papers in which he attacks sharply some of the methods and conclusions of the biometric school in the study of variation conclude Volume 1.

Volume 2 includes the papers on heredity and related subjects published by Bateson after the rediscovery of Mendel's law in 1900. This discovery furnished the key-note of all Bateson's subsequent work. He at last had found what up to this time he had been looking for. Mendel's law explained how discontinuous variations were perpetuated and why they were not swamped by crossing. He could now, with the aid of this law, not only see evolution at work, but also control its processes. This with a body of enthusiastic colleagues he now set about doing.

The first paper in Volume 2 is an introduction to an English translation of Mendel's brief but momentous paper published in 1866. The second paper is an exposition of Mendel's principles of heredity reprinted from a book of similar title published in 1902. This was an epoch-marking work which to most English-speaking readers brought the first information that a new day had dawned in the study of evolution. This message it brought in no uncertain terms. The complete failure as a generalized statement of facts of the Galton-Pearson law of ancestral heredity was pointed out, and in contrast it was shown that Mendel's law is a valid and easily verifiable principle governing the transmission of discontinuous genetic characters. The question was raised whether in last analysis all heritable variations would not be found to be discontinuous in character and subject to Mendel's law in transmission.

Next comes a partial reprint of the famous "Reports to the Evolution Committee" of the Royal Society on "The Facts of Heredity in the Light of Mendel's Discovery." In a footnote is suggested the now generally accepted terminology of generations concerned in a Mendelian cross, P_1 (parental), F_1, F_2, etc. (filial).

A paper on the present state of knowledge of color heredity in mice and rats (1903) summarizes the experiments made with these animals previous to and since the rediscovery of Mendel's law and shows that all are consistently Mendelian, notwithstanding the persistently maintained opposite view of the biometric school.

Later contributions deal with the inheritance of heterostylism in Primula (1905), walnut comb in fowls (1905), flower color in sweet peas and stocks (1906). An address before the International Zoological Congress held in Boston in 1907 deals with "Facts Limiting the Theory of Heredity." A paper on "The Heredity of Sex" (1908) deals with sex-linked inheritance in Abraxas first described in 1906 by Doncaster and Raynor. In the same year, "Reports to the Evolution Committee" describe experiments with poultry, sweet peas and stocks.

Subsequent papers are reprinted chiefly from the *Journal of Genetics* established by Bateson and Punnett in 1911. Their substance is known to most students of genetics. Comprehensive experiments with various plants and animals serve to extend the Mendelian principles or show their limitations. The reduplication hypothesis to explain the earlier discovered facts of coupling and repulsion is launched (1911) but partially withdrawn some years later in favor of Morgan's chromosome theory, in a paper on the "Genetics of *Primula sinensis*" (1923). The subjects of somatic segregation, of chimeras, of root-cuttings receive repeated attention. One is, in fact, amazed at the fruitfulness and the fundamental value of Bateson's investigations. A number of reviews of current publications on genetics and evolution complete Volume 2.

W. E. Castle

THE AMERICAN GEOPHYSICAL UNION

The tenth annual meetings of the American Geophysical Union and of its sections will be held in the National Academy and Research Council Building, Washington, D. C., on April 25 and 26, 1929. Following the business meeting of the general assembly of the union on the afternoon of April 26, the union will hear the five following general-interest papers presented by the Section of Oceanography, these all being either regarding work in progress or relating to work recently completed: "The Expedition of the Submarine *S-21* to the Caribbean Sea and Gulf of Mexico," by C. S. Freeman; "Oceanography and the Fisheries," by Henry B. Bigelow; "The International Ice Patrol, with Special Reference to its Economic Aspects," by Edward H. Smith; "The Cooperative

Survey of the Great Lakes," by Charles J. Fish; "The Work of the *Carnegie* to Date," by W. J. Peters.

The meetings of the six sections will be held on the mornings of April 25 and 26 and the afternoon of April 25. For each section short business meetings will be followed immediately by progress-reports and scientific papers. The section of geodesy (morning, April 25) will be devoted to progress-reports and recent developments in gravity and geodetic work in Mexico, Canada and the United States as follows: "Gravity-work in Mexico During the Past Year," by Pedro C. Sanchez; "Gravity-comparisons in Europe and America," by A. H. Miller; "The Measurement of Gravity at Sea," by F. E. Wright; "Recent Developments in Time-service Methods," by C. B. Watts; "Recent Developments in Geodetic Instruments," by D. L. Parkhurst; "Geodetic Work in Canada During the Past Year," by Noel Ogilvie; "Geodetic Computations and Investigations," by H. G. Avers; "Accomplishments in Field Geodesy During the Year April, 1928, to April, 1929," by William Bowie. The section of terrestrial magnetism and electricity (morning, April 25) will hear a symposium on physical theories of magnetic and electric phenomena, including the following papers: "The Corpuscular-ray Theory of Aurora," by N. H. Heck; "The Ultra-violet-light Theory of Aurora and Magnetic Storms," by E. O. Hulburt; "The Atmospheric Dynamo-theory of Variations in Earth-currents and Terrestrial Magnetism—A Review," by O. H. Gish; "A Tentative Theory of the Permanent Magnetic Field of the Sun and Earth," by Ross Gunn; "Echo-sounding of the Kennelly-Heaviside Layer," by M. A. Tuve.

The section of oceanography (afternoon, April 25) will hear the following communications: "Oceanography and Meteorology," by Charles F. Brooks; "Oceanography and Littoral Geology," by Douglas W. Johnson; "The Significance of Plankton Investigations," by Charles J. Fish; "Oceanographic Observations in Monterey Bay, California," by Henry B. Bigelow; "Recent Work on the Dynamic Oceanography of the North Atlantic," by C. O. Iselin; "Echo-sounding," by W. E. Parker. Additional oceanographic papers of general interest in this vast field will be presented as indicated above at the general assembly on the afternoon of the following day. The section of volcanology (afternoon, April 25) will hear and discuss the following papers: "Volcanic Oceanic Islands," by H. S. Washington; "Volcanoes of Java and Bali," by E. G. Zies; "The Volcanic History of the San Juan Mountains, Colorado," by E. S. Larsen; "Recent Eruptions of Kilauea," by T. A. Jaggar.

The sections of meteorology and seismology will hold meetings on the morning of April 26. The first will be devoted to the report of the meteorological division of the committee on the physics of the earth, which will include the following: "Introduction," H. H. Kimball; "The Origin and Composition of the Atmosphere," by W. J. Humphreys; "Meteorological Data and Meteorological Changes," by C. F. Marvin and A. J. Henry; "Solar Radiation and its Rôle," by H. H. Kimball; "Meteorology of the Free Atmosphere," by W. R. Gregg; "Dynamic Meteorology," by Edgar W. Woolard and Hurd C. Willett; "Physical Basis of Weather Forecasting," by Carl-Gustaf Rossby and Richard H. Weightman. The scientific program of the section of seismology will include: "Surface-waves," by J. B. Macelwane; "Forces and Movements at the Earthquake-origin," by H. F. Reid; "The Velocity of Surface-waves," by F. Neumann; "The Seismicity of the Arctic as Indicated by Instrumental Data," by E. A. Hodgson; "Earth-vibrations from Dynamite Blasts," by L. D. Leet.

The scientific sessions are open to persons interested in geophysics, whether members of the union or not, and all such are cordially invited to attend. These annual meetings are increasingly interesting each year, not only because of the stimulus afforded the study of problems concerned with geophysics but also by reason of the cooperation of the corresponding geophysical organizations of Canada and Mexico which is making for initiation and coordination of geophysical researches depending upon international and national cooperation.

JNO. A. FLEMING,
General Secretary

SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE IN VIVO CULTIVATION OF INTESTINAL PROTOZOA IN PARASITE-FREE CHICKS

As every one knows, who has attempted experiments with animal parasites in laboratory animals, one of the greatest difficulties is to secure parasite-free animals for infection purposes. During the past two years a number of interesting experiments have been carried on in this laboratory with parasite-free chicks. Chicks offer a number of advantages; they can be obtained at any time of the year; they are free from animal parasites when they hatch from the egg; they are very inexpensive; they can be maintained in the laboratory free from animal parasites without difficulty and at low cost, and they can be inoculated very easily per os or per rectum with material containing animal parasites.

Fowls are known to be infected in nature by a number of intestinal protozoa; these include amebae,

flagellates and coccidia. Among the five hundred or more chicks that we have used in this laboratory only one group of half a dozen have ever become infected with protozoa other than those inoculated into them. This group became infected with coccidia, and it seems evident that greater precautions are necessary to prevent contamination under ordinary laboratory conditions with this type of protozoon than with amebae, flagellates or ciliates.

Besides being parasite free and easily maintained in this condition, chicks are favorable for experimental studies because one can obtain samples from the cecum, where intestinal protozoa seem to be almost entirely localized, without killing the birds or resorting to surgical operation. At first in our experiments chicks were inoculated and then killed at various time intervals. Later it was found that the contents of the cecum are evacuated from time to time and that this material can be distinguished easily from the intestinal contents passed in the form of feces. The fecal material is usually compact and dark in color, whereas the cecal contents are more liquid and yellowish in color. The best way to obtain cecal material seems to be to give the chicks fresh food and water early in the morning and then place them under glass dishes on paper towels. Here they can easily be watched until cecal material is passed. Some of the chicks will not evacuate their cecal contents for several hours, but most of them will deposit the desired material within a few minutes.

The method of procedure followed was usually as follows. The protozoa to be inoculated were obtained either from cultures grown in test-tubes or from fecal material. If from the former, a more concentrated inoculum was sometimes prepared by centrifuging the culture medium and pouring off most of the supernatant fluid. If the trophozoites of protozoa were located in fecal material, this mass was diluted with normal saline solution and passed through cheese-cloth to remove all coarse particles that might otherwise clog the passage through the tube used for inoculation. Protozoan cysts may be secured in large numbers by any of the concentration methods devised for this purpose. A simple method is to stir up the infected fecal material in several liters of water in a tall, narrow cylinder; allow the cysts to settle to the bottom, which requires about thirty minutes, then pour off most of the supernatant fluid, fill the cylinder with water, stir up thoroughly and allow the cysts to settle again. After this has been repeated several times the cysts are well washed and concentrated.

A 5 cc Luer syringe to which was attached a rubber catheter shortened to a length of about 10 cm was used for inoculating material into the chicks. Most of the chicks were about four days old, although older birds were used for studies of age resistance. The amount of inoculum depends on the age (size) of the chick. From 2 to 4 cc of material can be injected into the crop of a four-day-old chick by lubricating the catheter with vaseline, inserting it down the throat with one hand while the bird is held in the other, and then slowly pushing down the plunger of the syringe. Similarly from 1 to 3 cc can be injected into the rectum. The catheter should be inserted about 2 or 3 cm. The anal opening should be held closed with the fingers for a few seconds after the catheter is removed. Material injected into the rectum appears to find its way immediately into the ceca.

The ceca of a four-day-old chick are located about 3 cm from the anus. They are thin-walled sacks about 3 cm long and open into the intestine through small pores. Protozoa inoculated either per os or per rectum very quickly become located in the ceca, although those inoculated by mouth must pass through the stomach, small intestine and large intestine before reaching the ceca and hence not such a large proportion of them actually enter the ceca as of those inoculated per rectum. A sufficient number of experiments were performed to demonstrate that the trophozoites as well as the cysts of many protozoa are able to pass through the stomach and small and large intestine of both young and older chicks and reach the ceca in a viable condition.

The results of introducing intestinal protozoa from man and other animals into chicks have been prepared for publication elsewhere (Hegner, 1929).[1] They indicate that infections can be set up easily in the ceca with a number of species of amebae, flagellates and ciliates. Some of the infections continued for over six months and apparently would have remained indefinitely. Among the protozoa used were *Trichomonas hominis* from the human intestine and *T. buccalis* from the human mouth. These were maintained in chickens for over four months when the experiments were terminated. It thus seems probable that chickens may serve as transmitting agents of human intestinal protozoa.

One of the most interesting results of the experiments was the discovery that the chick may be used as a sort of *in vivo* test-tube for the cultivation of intestinal protozoa. For example, cecal material from a guinea-fowl which was found by the ordinary smear method to contain a very few trichomonads was injected per rectum into chicks. Two days later large numbers of trichomonads, *Chilomastix,* and *Endolimax* amebae were present in cecal material evacuated by the chicks. The trichomonads appeared to

[1] To be published in the *American Journal of Hygiene.*

belong to two or three different species. Both trophozoites and cysts of the *Chilomastix* were present. The *Endolimax* amebae appeared to belong to two different species, and both trophozoites and cysts were present in abundance. On the third day the trophozoites of a large *Endamoeba* were found; these became abundant on the fourth day and cysts were present on the ninth day. It is evident that conditions in the ceca of these four-day-old chicks were particularly favorable for the growth and reproduction of these protozoa and that the specimens of *Chilomastix, Endolimax* and *Endamoeba* would not have been discovered by the examination of the cecal material from the guinea-fowl by the smear method. Protozoa not observed in the ceca of the duck, goose and screech-owl were likewise discovered in the cecal material evacuated by chicks that had been inoculated with material from these hosts. These results were not due to the accidental infection of the chicks in the laboratory, since control chicks of the same brood that were kept in neighboring cages and were fed from the same food supply remained uninfected.

This work indicates that protozoa too few in number to be found in smears made from the cecal contents of birds such as guinea-fowls, ducks and geese grow and multiply so rapidly when inoculated into parasite-free chicks that they can not only be demonstrated without difficulty but can be secured in sufficient numbers to prepare permanent slides for the detailed study of their morphology. Data already obtained by the use of fecal material from other animals inoculated into chicks suggest that this method of cultivating intestinal protozoa *in vivo* in chicks can be extended to include species from other types of animals, especially mammals. If this proves to be true it will be a relatively simple matter to make an accurate survey of the intestinal protozoa of any particular species of host.

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SPECIAL ARTICLES

IS THE TWELVE-HOUR VARIATION IN ATMOSPHERIC PRESSURE AN ELECTRIC PHENOMENON?

HANN, in his "Lehrbuch der Meteorologie," p. 177, says (translation by present writer):

> No other meteorological element has so regular a daily period as the atmospheric pressure; and this in spite of the fact that the amplitude of this daily variation is relatively small, ranging from two or three millimeters in the tropics to a few tenths of a millimeter at 60° latitude. The daily period is double; the atmospheric pressure reaches twice daily a maximum and twice a minimum, and, where the daily atmospheric pressure is least disturbed, both maxima and minima are very much alike. This is very different from the daily range of other meteorological elements, and suggests the ebb and flow of the sea, for which reason these waves have been called atmospheric tides. In spite of their resemblance in form, an important difference in the two phenomena appears in that the "atmospheric ebb and flow" follows the sun and occurs according to true local time, and that no lunar influence is perceptible in it. Accordingly, it can not be a gravitation phenomenon, since in that case the lunar period would be much more strongly marked than that of the sun.
>
> The phenomenon has, accordingly, a much greater theoretical interest than the daily periods of the other meteorological elements, which, although much less simple and locally much more variable, yet can be definitely shown to depend upon the conditions of insolation. Practically, on the contrary, the daily barometric variation, on account of its minuteness, is of little significance and can scarcely be related to any consequences, while the daily period of temperature, for example, is regarded as of great importance and occupies a very conspicuous place in the domain of meteorology.

A remarkable characteristic of the semi-diurnal barometric variation is the regularity of the occurrence of the maxima and minima and their uniformity in time of day in all latitudes. While the amplitude of these waves may vary greatly with latitude, with elevation and with location, whether over the sea or over the land, the local times of maxima and minima are very constant. This is true also for the different periods of the year, though the amplitude of variation is everywhere greatest at the equinoxes and least at the solstices. In tropical regions the influence of the weather, whether rain or wind, except the great whirling storms, has little effect upon the semi-diurnal barometric fluctuations.

The many differences between this phenomenon and the other meteorological phenomena seem to point to some agency which does not affect the other meteorological elements, but no such agency has hitherto been discovered. It is well understood that the barometric height varies with the temperature and with the moisture content of the air, but these variations, while they must necessarily have a twenty-four-hour period, are very irregular at any single location and vary greatly, both in time and amplitude, at different places. Accordingly, while the two variations are always superposed, the semi-diurnal variation possesses much more the character of a regular sine wave than does the twenty-four-hour variation. For this reason the many attempts to separate the barometric wave by means of harmonic analysis into a daily and a half-

daily wave have failed, and no one knows the true form of either component.

The results of one attempt to analyze the daily barometric wave into harmonic components, made by W. J. Bennett, were published[1] in 1906. Bennett used the mean daily variation of the barometer at Washington, D. C., for fourteen years, and attempted to analyze the resulting curve into four harmonic components, one of which had a twenty-four-hour period, one a twelve-hour period, and the other two had shorter periods and small amplitudes. His results are given for the whole year and for the months of January and July. The three sets of curves are very similar, and the July curves are chosen for consideration in this paper. The experimental curve and the twenty-four-hour and twelve-hour theoretical curves are shown in Fig. 1. The experimental curve is given by the continuous line and the two theoretical curves by the dashed lines.

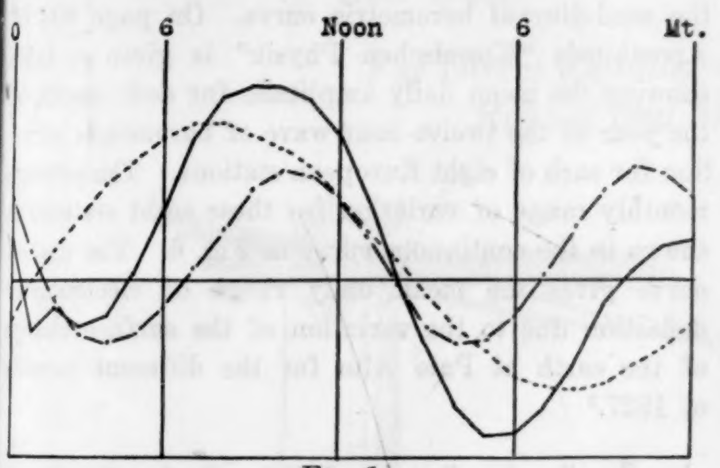

FIG. 1

That these two curves together do not make up the barometric curve may be seen by subtracting the twelve-hour curve from the observed barometric curve and observing the difference between the resultant twenty-four-hour curve and the theoretical twenty-four-hour curve given in Fig. 1. This difference is shown in Fig. 2, where the continuous line shows the computed twenty-four-hour curve and the dashed line shows the curve given by subtracting the computed twelve-hour curve from the barometric curve.

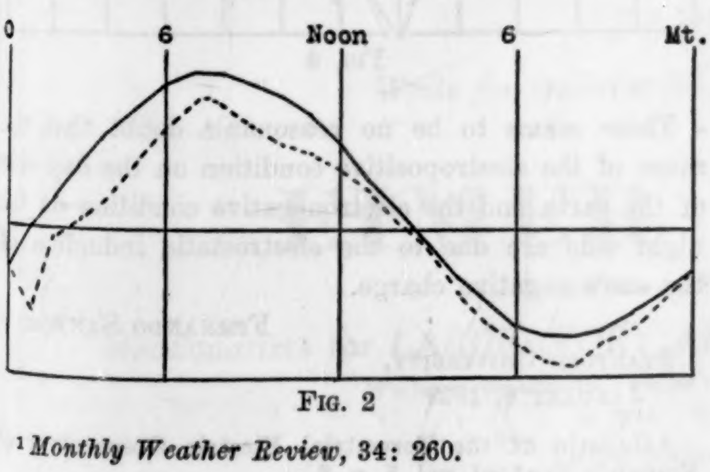

FIG. 2

[1] *Monthly Weather Review*, 34: 260.

In a paper[2] read before the American Physical Society at the Pomona meeting, June 15, 1928, and in a footnote on page 65 of SCIENCE of July 20, 1928, is described a method of proving that the surface charge of the earth undergoes a daily variation at a given place, so that the earth becomes most electropositive to insulated bodies above its surface at from ten to eleven A. M., and most electronegative to such bodies at about seven or eight P. M. This phenomenon may be shown by removing one pair of diagonal quadrants from an ordinary quadrant electrometer, putting the metallic needle suspension into electrical contact with the remaining pair of quadrants and insulating the system thus formed of the needle and quadrants inside a grounded metal case with no battery or artificial charge in its vicinity. If such system be discharged to earth and allowed to stand, the electrometer needle will go through a double diurnal deflection, having its neutral points at about seven A. M. and three P. M. Since the electrometer needle will be repelled by the quadrants when they are both charged alike relative to the earth, one of the semi-diurnal deflections will occur when they are thus positively charged and one when they are negatively charged.

Fig. 3 shows the mean daily deflection for twenty days in May, 1928, of two electrometers set up in this way upon the same pier and recording photographically upon the same drum. The two electrometers were of different size, different construction and different sensitivity. The daily deflections were closely proportional to the sensitivities of the respective instruments, and their average daily magnitude was greater than was produced by charging the instruments up to 150 volts.

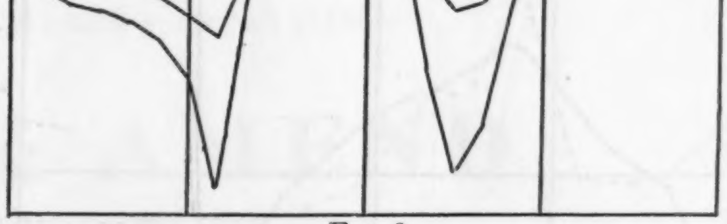

FIG. 3

The results of this and other similar experiments show that *any unelectrified, insulated body near the*

[2] Abstract in *Phys. Rev.*, 32: 325. August, 1928.

earth, even if inside a closed hollow conductor, will be attracted twice daily by the electric charge of the earth, and it has seemed possible that the semi-diurnal variation in barometric pressure may be due in some manner to this attraction. To test this surmise the diurnal variation in barometric pressure as shown by the microbarograph was measured and recorded for the same twenty days for which the electrometer deflections were recorded. The curve given by the barometric variations is compared with the mean of the two electrometer curves in Fig. 4, where the continuous line shows the barometric variation and the dashed curve shows the mean of the daily variations of the two electrometers.

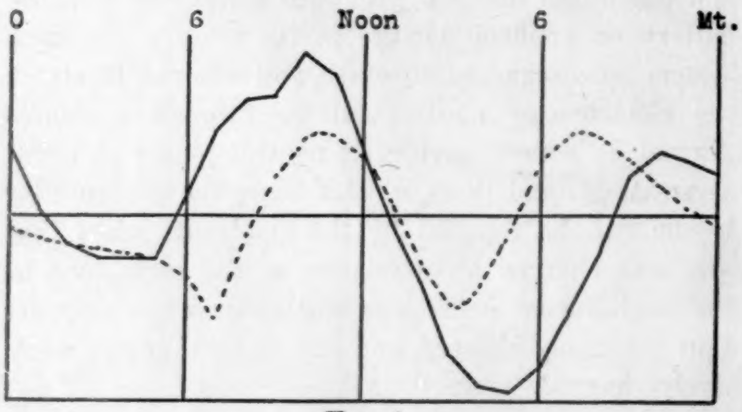

Fig. 4

It will be seen that neither of the experimental curves given in this figure is a sine curve, but the electrometer curve is more nearly one than is the barometer curve. It is also quite as regular on successive days as is the barometer curve, and Fig. 3 shows that its periodicity is the same for the two electrometers. If the semi-diurnal variation in barometric pressure is due to the same cause as the semi-diurnal electrometer deflection, and if it be subtracted from the total barometric variation, it should leave a twenty-four-hour curve due to the various disturbances which depend upon solar radiation and other possible disturbances. When this is done, the dashed curve in Fig. 5 is given. The continuous curve in the same figure is the same as the dashed curve in

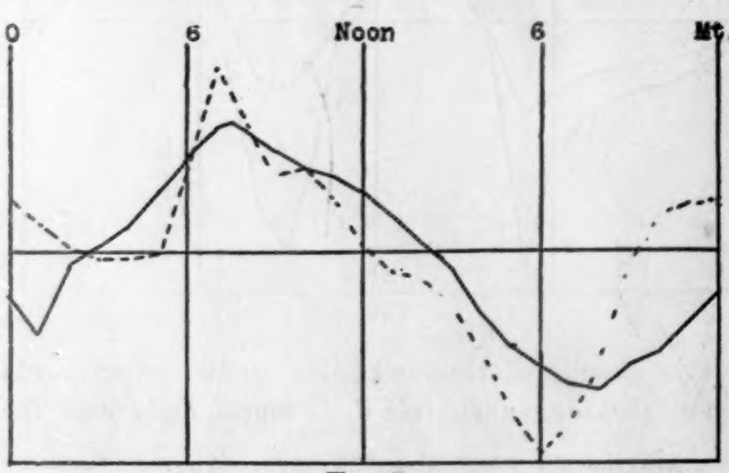

Fig. 5

Fig. 2, *viz.*, the curve given by subtracting Bennett's theoretical twelve-hour curve from his total barometric curve. Both curves indicate a similar form for the twenty-four-hour curve, that is, a maximum about seven A. M. and a minimum from six to eight P. M.

No one knows what form this curve should take. The daily range of air temperature at any given place is very irregular, and as it is always different at different altitudes above the ground, no one knows at what height its variations agree most closely with the twenty-four-hour barometric range.

One thing which seems certain about the semi-diurnal barometric variation is that it is caused in some manner by solar influence. This is shown by both its daily and seasonal variations. Also, the semi-diurnal electrometer deflection must be due to the sun, as it has both a daily and a seasonal variation, being of greatest amplitude at the equinoxes and least at the solstices. In this respect it agrees closely with the semi-diurnal barometric curve. On page 603 of Arrenhius's "Kosmischen Physik" is given a table showing the mean daily amplitude for each month of the year of the twelve-hour wave of barometric variation for each of eight European stations. The average monthly range of variation for these eight stations is shown in the continuous curve in Fig. 6. The dashed curve gives the mean daily range of electrometer deflection due to the variation of the surface charge of the earth at Palo Alto for the different months of 1927.[3]

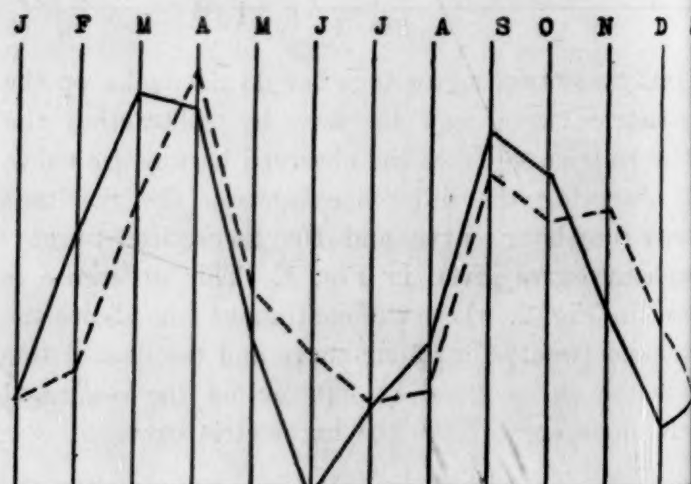

Fig. 6

There seems to be no reasonable doubt that the cause of the electropositive condition on the day side of the earth and the electronegative condition on the night side are due to the electrostatic induction of the sun's negative charge.

FERNANDO SANFORD

STANFORD UNIVERSITY,
JANUARY 8, 1929

[3] Bulletin of the Terrestrial Electric Observatory of Fernando Sanford, vol. 5, p. 8.